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The Role of Chemistry Teachers' Functional Paradigms in Translating Curriculum Materials into Classroom Practice

University — Université
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Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée
Doctor of Philosophy

Year this degree conferred — Année d'obtention de ce grade
1984

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THE ROLE OF CHEMISTRY TEACHERS' FUNCTIONAL PARADIGMS IN TRANSLATING CURRICULUM MATERIALS INTO CLASSROOM PRACTICE

by

OLIVER CHARLES LANTZ

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA
FALL 1984

THE UNIVERSITY OF ALBERTA

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Abstract

The study is an examination of the interpretive process used by high school chemistry teachers in translating curriculum materials into classroom practice. The context of the study is high school chemistry, with the ALCHEM materials (Jenkins et al, 1976) providing an example of a specific set of curriculum materials. The data collection and analysis in the study was guided by the following four questions:

1. What is the nature of teachers' functional paradigms as represented by the way they interpret curriculum materials?
2. What are some of the factors which influence teacher interpretation of curriculum materials?
3. What are some of the relationships among the these factors?
4. What would be some of the characteristics of a model of teacher interpretation of curriculum materials which is based on data derived from the study?

The data for the current study were collected using both qualitative and quantitative approaches. Qualitative data were gained principally from observations and interviews with three selected chemistry teachers working in different school settings. Each school site was visited five times over a period of four months. The quantitative methods included developing and administering a Student Opinion Survey (SOS) to the students of the three teachers who were observed and interviewed. In addition, the Chemistry Classroom Practice Survey (CCPS) was developed and administered to a randomly selected sample of Alberta chemistry teachers. The survey sample was drawn by randomly selecting 50 high schools from the 242 Alberta schools which offer a complete high school chemistry program.

The interview transcripts and the responses to the open-ended questions in the CCPS were analyzed by categorizing the statements as they related to the four curriculum commonplaces (Schwab, 1971): chemistry, teaching, students, and school setting. Recurring themes were then sought within each of these categories. The numerical data were entered directly into a computer file and were analyzed using standard programs from the Statistical Package for the Social Sciences (SPSS) library (Nie et al, 1975).

One outcome of the study is a model of teacher interpretation of curriculum materials which uses the concept of a functional paradigm as a central construct. The model is used to explain the interpretive patterns of the chemistry teachers in the study sample and the influences underlying these patterns. The model relates the following four points which summarize the major findings of the study.

1. Data from the study indicate that chemistry teachers place a high value on teaching theoretical chemistry and a low value on teaching the science-technology-society connection and the nature of science.
2. The data from the study suggest that teaching concerns are paramount considerations of teachers when they translate curriculum materials into classroom practice. In particular, chemistry teachers develop teaching techniques and classroom routines which stress pedagogical efficiency, academic rigor, and motivation of students.
3. The data indicate that the academic history of teachers plays a large part in shaping their functional paradigms. Training in chemistry and experience in teaching different chemistry programs are identified as factors which have a particularly strong influence on teacher interpretation of curriculum materials.
4. The data also suggest that a teaching situation has a significant effect on how curriculum materials are interpreted. In particular, the teaching assignment (including both number of students and number of different subject taught), number of colleagues, and school resources seem to be significant factors.

Acknowledgments

My sincere thanks go to the members of my advisory committee, Dr. Heidi Kass, Dr. Marshall Nay, Dr. Al Olson, Dr. Larry Beauchamp, and Dr. John Martin, for their advice and encouragement throughout the design and execution of the study. In particular, the valuable suggestions and prompt feedback of my advisor, Dr. Heidi Kass, are very much appreciated. My thanks go also to Dr. Steve Hunka for his advice concerning data analysis, and to Dr. Mick Connelly of O.I.S.E. for helping me clarify the initial idea for the study.

I am indebted to the many Alberta chemistry teachers and students who responded to my questionnaires. I am particularly indebted to four teachers (referred to in the dissertation as Mr. Brown, Mr. Allan, Mr. Jensen, and Mr. Kurelek) who gave their time for interviews and allowed me to observe and survey their classes. The members of the ALCHEM author group and the chemistry teachers at Harry Ainlay Composite High School provided constructive criticism of the initial drafts of the survey instruments used in the study. The staff in the Faculty of Education Publications Services helped me with the intricacies the word processing facilites of the U of A Ahmdahl computer. To all these people, my hearty thanks.

Finally, I wish to thank my wife, Helen, and my three sons, Kevin, Mark, and Trevor. Their loving support, encouragement, and understanding made the completion of the study possible. To my family, I dedicate this dissertation.

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I. THE PROBLEM

A. Background to the Problem

The nineteen-sixties and seventies were extraordinary decades for curriculum (Connelly and Elbaz, 1980). The launching of Sputnik, by the USSR in October of 1957, prompted the development of numerous new science and mathematics curricula throughout the Western World. Many new curricula such as BSCS, CHEM Study, and PSSC, were developed by generously funded projects under the sponsorship of governments and foundations while others, such as ALCHEM in Alberta, were developed by local teams of teachers operating on more modest budgets. The development of new curricula fostered the growth of the field of curriculum studies to include the subfields of curriculum development, curriculum implementation, curriculum decision-making, curriculum evaluation, and curriculum theory.

The curriculum evaluation and curriculum implementation studies which followed in the wake of the new science and mathematics curricula revealed that the considerable resources of time, talent, and money which were invested in curriculum developments during the sixties and seventies did not produce a proportionate change in classroom practice (Stake & Easley, 1978; Fullan, 1982). While some of the curriculum developments of the nineteen-sixties and seventies did take root in the schools (Welch, 1979), many of them have been regarded as failures in some quarters because they did not meet their intended objectives. For example, the emphasis placed on the process of science and discovery learning in many curriculum developments has not been reflected in classroom practice (Welch, 1979; Orpwood & Souque, 1984). The view that many high-priced programs have been failures is often accompanied by cynicism about the possibility of significant educational change. This cynicism, coupled with the financial restrictions of the nineteen-eighties, will likely make the next decade an inclement time for curriculum development and innovation. At the same time, formal education cannot escape fundamental alterations if it is to respond positively to the broad social, environmental, and economic forces currently acting on it (Leithwood, 1981).

Recognition by educators of the continued need for curriculum development and innovation has led to an active study of curriculum implementation, which is generally regarded as the weak link in the process of translating curriculum innovations into classroom practice (Fullan & Pomfret, 1977). During the last ten years there has been a "cascade" of works on the implementation of curriculum innovations (House, 1979). Unfortunately, in many such implementation studies teachers are regarded as mere "delivery agents" whose resistance to change is blamed for the failure of curriculum implementation (Connelly & Ben-Peretz, 1980). Empirical implementation studies have shown that teachers do not neutrally implement programs, but rather adapt, translate, and modify given materials for use in their own classrooms. Only recently has consideration been given to the possible positive contributions that can be made to classroom practice by teachers drawing on their own practical knowledge of the subject, the students, teaching strategies, and their own situation (Connelly & Elbaz, 1980). It seems likely that the discrepancy between the intentions of school authorities and curriculum developers, on one hand, and the actions of classroom teachers on the other is at least partly due to different interpretations of the meaning of the statements in curriculum documents and materials.

B. Personal Ground

My interest in studying the interface between the intended curriculum and classroom practice stems from my experience in curriculum development. During the ten year period from 1974 to 1984, I worked on the Edmonton Public School Board (EPSB) curriculum project which developed the ALCHEM program (Jenkins et al, 1976). The ALCHEM project began in 1973 as a result of teacher dissatisfaction with the existing Alberta high school chemistry program. The dissatisfaction focused on CHEM Study (Pimentel, 1963), an NSF funded program, which had been authorized by the Alberta Department of Education for use in teaching senior high school chemistry. Many teachers felt that the CHEM Study program emphasized theoretical chemistry at the expense of applied and descriptive chemistry. In addition, the presentation of the chemistry content in the CHEM Study text was regarded by many teachers as pedagogically unsound, in that basic introductory concepts were developed from gas phase properties, an approach which was considered too abstract for most beginning high school students.

In the Autumn of 1972, concern over the existing Alberta high school chemistry program led to the re-activation of a high school chemistry teachers group, the Edmonton Regional Chemistry Council (ERCC). This organization served as the forum for discussing mutual concerns among Edmonton area chemistry teachers. Consensus emerged among the teachers active in the ERCC that some materials to replace the existing chemistry program could and should be written locally. To this end, in the Spring of 1973, two Edmonton high schools jointly submitted a request to the EPSB for funding for an action research project aimed at producing some materials for use in the Chemistry 10 course. The request was granted, and the first draft of ALCHEM 10 was written during the Summer of 1973. The ALCHEM 10 materials were piloted in four schools the following school term and were subsequently rewritten. The same pattern of summer writing, followed by classroom piloting and rewriting, was followed in developing the ALCHEM 20 and 30 core materials as well as seven elective units, over a six-year period During this time the number of teacher authors grew from four to nine and the method of production advanced from school gestetner to commercial printing. The funding for the ALCHEM project was provided by the EPSB, with the exception of the stipend paid by the Edmonton Catholic School District for one teacher-author for three summers.

In 1977 the ALCHEM program was authorized by the Alberta Department of Education as one of the recommended texts for the high school chemistry program in Alberta, and now ALCHEM holds approximately eighty percent of the Alberta market. The ALCHEM materials have been authorized for use in Manitoba, Newfoundland, Nova Scotia, and New Mexico, by the respective Ministries of Education, and are also used extensively by individual schools and teachers across North America.

My own involvement in the development of ALCHEM stems from its origins in the meetings of the ERCC. I was one of the teachers who piloted the first draft of ALCHEM 10, and I joined the writing team in the Summer of 1974. My work on the ALCHEM project consisted of helping plan the content of the units, writing and rewriting specific units, critiquing the writing of other authors, and proofreading typed copy. As a pilot teacher, I evaluated the materials based on my classroom experience with them, making note of errors and weaknesses which could be removed in the next revision.

Much of the time during piloting was spent on modifying laboratory experiments so that they would produce the desired results in the hands of the students.

In my concurrent experience as head of a science department where the ALCHEM materials were being used, I found that while teachers were generally quite enthusiastic about the content and format of the materials, they often used the materials differently than the writing team had intended. Sometimes the teachers de-emphasized the applied and descriptive chemistry in favor of more emphasis on theory, and sometimes teachers ignored the aspects of the materials that were designed to address issues of science and society and the nature of science. It seemed that many chemistry teachers interpreted the ALCHEM materials quite differently than the ALCHEM writers intended. Although all the chemistry classes in the school were using the ALCHEM materials, and the students wrote common midterm and final exams in each chemistry course, it seemed likely that the meta-lessons that the students received on the nature of chemistry depended to a large extent on who their teacher was. My experience with implementing the ALCHEM program bears out the following assertion:

> There can be no significant innovation in education that does not have at its center the attitudes of teachers, and it is an illusion to think otherwise. The beliefs, feelings and assumptions of teachers are the air of a learning environment; they determine the quality of life within it. (Postman & Weingartner, 1969, p. 33)

That classroom teachers play a critical role in determining curricular outcomes as they translate the intended curriculum into classroom practice has been acknowleged by many contemporary curriculum theorists (Connelly & Ben-Peretz, 1980, Connelly & Elbaz, 1980, Fullan, 1979, Leithwood, 1982, Schwab, 1969, 1971, 1973). Since the intentions of curriculum developers are operationalized in the materials they develop, a thorough examination of the interpretative process used by teachers in deriving their personal meaning of curriculum materials should reveal some of the characteristics of this phenomenon and should contribute toward developing a theoretical basis for viewing implementation which is useful to both practioners and curriculum researchers.

C. Statement of the Problem

The study is an examination of the interpretive process used by high school chemistry teachers in translating curriculum materials into classroom practice. The context of the study is high school chemistry, with the ALCHEM materials providing an example of a specific set of curriculum materials. The focus of the study is on how chemistry teachers interpret the ALCHEM materials for use in their classrooms, not on evaluating the materials themselves.

D. Definition of Terms

The key terms used in the study are defined as follows:

ALCHEM: a two-year high school chemistry core-elective program which was originated, written, piloted, evaluated, implemented, and repeatedly revised by a team of classroom teacher-authors (Jenkins & Kass, 1980).

chemistry major: a teacher who has completed more than three full courses in university chemistry.

Chemistry Classroom Practice Survey (CCPS): A 90-item questionnaire designed to capture information about Alberta high school chemistry teachers and their classroom practice. The items in the CCPS use multiple choice, Likert rating scale, and open-ended format.

classroom observations: the researcher's perceptions of the physical features and organization of a classroom, the size and nature of the classes taught there, and the teaching strategies used, particularly as they relate to curriculum materials.

classroom practice: all of the teaching activities carried out by the teacher, including selection and use of commercial materials, development and use of additional materials (e.g., notes, experiments, and demonstrations), presentation of course content, and evaluation of student achievement.

factors: agents which contribute to an effect. The study attempts to identify factors which influence teachers' interpretation of curriculum materials.

focused interview: a conversation in which the interviewer uses questions to focus the discussion on a certain theme. Focused interviews were used in the study to gather information on teachers' use of a particular set of curriculum materials.

functional paradigm: the constellation of beliefs, values, techniques, exemplars, and routines shared by a group of teachers and used by them to guide their classroom practice (Kuhn, 1970; Imershein, 1977; Crocker, 1983).

interpretation: a formative process in which meanings are used and revised as instruments for the guidance and formation of action (Blumer, 1969). Classroom teachers' interpretations of curriculum materials are the focus of the study.

meanings: mental creations that are formed in and through the defining activities of people as they interact (Blumer, 1969). The study examines the meanings that classroom teachers ascribe to various aspects of a specific set of curriculum materials.

perceptions: an individual's view of a subject. In the study, classroom teachers' perceptions of chemistry, teaching, students, and school setting, are used to categorize some of the factors which influence teachers' interpretation of curriculum materials for use in their classroom.

perception of chemistry: an individual teacher's view of what high school chemistry ought to be, including topics to be covered, adequate levels of treatment, and the role of laboratory work.

perception of school setting: an individual teacher's view of school facilities, local community concerns, as well as broader social concerns.

perception of students: an individual teacher's view of the needs, abilities, and interests of students.

perception of teaching: an individual teacher's view of the the requirements for effective teaching, as well as the overall aims of teaching.

rural school: a school located in a community (i.e., city, town, or village) which has a population of less than 30 000.

stated curriculum: the Alberta chemistry curriculum as outlined in the document, *Curriculum guide for senior high school chemistry* (Alberta Education, 1977).

Student Opinion Survey (SOS): A 42-item questionnaire in which high school chemistry students were asked to rate, on a five-point Likert scale, 14 aspects of the ALCHEM materials. Each aspect of ALCHEM was rated from three points of view.

urban school: a school located in a city which has a population of 30 000 or more.

E. Guiding Questions

The research is guided by the following four broad questions:

1. What is the nature of teachers' functional paradigms as represented by the way they interpret curriculum materials?
2. What are some of the factors which influence teacher interpretation of curriculum materials?
3. What are some of the relationships among the these factors?
4. What would be some of the characteristics of a model of teacher interpretation of curriculum materials which is based on data derived from the study?

F. Design of the Study

Both qualitative and quantitative approaches were used in developing the data base for the current study. The principal sources of the qualitative data were observations and interviews with three chemistry teachers working in different school settings. Each school site was visited five times, over a four-month time span. The teacher interviews involved asking the teachers about the methods and materials that they use in teaching high school chemistry and attempting to uncover reasons for their particular classroom practices. Classroom observation, teacher prepared materials, school documents, and interviews with school administrators supplement the qualitative data. Points noted during the observations of students and teachers working in the classroom and laboratory, and in the examination of teacher developed notes, worksheets, and tests, were discussed in the teacher interviews. The quantitative methods included developing and administering to a randomly selected sample of Alberta chemistry teachers, a Chemistry Classroom Practice Survey (CCPS). In addition, a Student Opinion Survey (SOS) was developed and administered to the chemistry classes of the three teachers who were observed and interviewed.

Timeline for the Data Collection

The data collection for the study proceeded in the following three stages:

Stage 1: October to December, 1982

- observation and interview techniques piloted with one chemistry teacher.
- the Student Opinion Survey (SOS) prepared and piloted with students of the chemistry teacher.

Stage 2: January to April, 1983

- three school sites selected for observation and interviews.
- teacher interviews and classroom observations carried out.
- the SOS administered and analyzed.
- the SOS responses discussed with teachers.
- the Chemistry Classroom Practice Survey (CCPS) prepared.

Stage 3: May and June, 1983

- a random sample of Alberta high school selected.

- permission to mail CCPS to sample schools requested from respective school superintendents.
- the CCPS mailed to principals of sample schools.
- the results of returned CCPS collated and analysis begun.

Delimitations

1. The stated curriculum was delimited to the chemistry program outlined in the document, *Curriculum guide for senior high school chemistry* (Alberta Education, 1977).
2. The duration of data gathering was delimited to the Spring semester of 1983. The assumption is made that chemistry teachers' classroom practice will not vary significantly from one semester to another.
3. The observation and discussion of classroom practice was delimited to chemistry classes. The teachers approach to teaching other subjects or leading extracurricular activities was not examined.
4. The ALCHEM materials (Jenkins et al, 1976) were used in the study to provide a specific set of curriculum materials so that classroom teachers' interpretation could be examined. The use of ALCHEM in other provinces was not examined, nor was the use of other authorized chemistry references in Alberta. This delimitation was intended to hold the curriculum materials constant so that the interpretive process used by teachers could be more readily compared. No attempt is made to evaluate the ALCHEM materials.
5. The classroom observations were delimited to gathering data about the teacher's working environment and classroom teaching practices, particulary as they relate to use of the ALCHEM materials. The classroom observations formed the basis of some of the subsequent discussions with the teacher.

Assumptions

1. Classroom teachers' interpretation of curriculum materials will be reflected by their accounts of how they use the materials in their classrooms.

Limitations

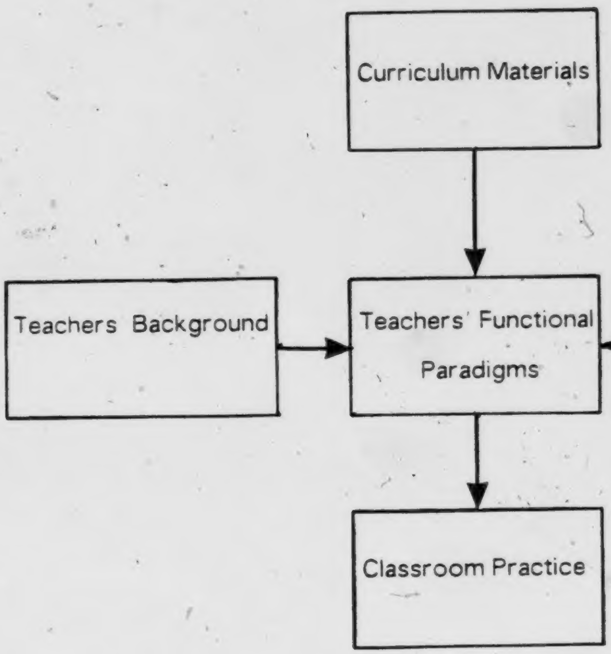
1. The examination of teacher interpretation of curriculum materials is based of the ALCHEM materials. Generalization of the findings of the study to other chemistry programs must be done with caution.
2. The study is limited to an analysis of linguistic symbols, in particular, teachers' interpretation of printed materials.

G. Theoretical Framework of the Study

The current study is an investigation of the role of chemistry teachers' functional paradigms in translating curriculum materials into classroom practice. In addition, the study seeks to identify some of the factors which influence teacher interpretation of curriculum materials. Two categories of factors are anticipated; those coming from the teacher's background, and those coming from the teacher's current teaching situation. These aspects of the study are represented schematically in Figure 1.

The theory of personal knowledge used in the study is that of symbolic interactionism, and it is in this sense that the terms *meaning* and *interpretation* are used. A brief outline of the symbolic interactionist approach is given here, and its key concepts and underlying assumptions are described and discussed in more detail in Chapter 2. Symbolic interactionism is based on the following three assumptions (Blumer, 1969):

1. Human beings act toward objects on the basis of the meanings that the objects have for them.
2. The meaning of objects is derived from, or arises out of, the social interaction that one has with one's fellows.
3. These meanings are handled in, and modified through, an interpretive process used by the person in dealing with the objects he encounters.


Curriculum Materials
Teachers Background
Teachers' Functional Paradigms
Teaching Situation
Classroom Practice

Translating Curriculum Materials into Classroom Practice

Figure 1.

In symbolic interactionism an *object* is regarded as anything that can be refered to or indicated. Objects can be classified into three general categories: physical objects, such as books and bunsen burners; social objects, such as students and colleagues; and abstract objects, such as concepts and principles. The study is based on the following three premises which parallel those of symbolic interactionism.

1. Chemistry teachers' use of curriculum materials will be determined by the meaning that curriculum materials have for them, not by curriculum materials *per se*.
2. The meaning of curriculum materials for chemistry teachers arises out of the interaction they have with others regarding them, e.g., students, colleagues, curriculum supervisors, university instructors.
3. The meaning of curriculum materials for chemistry teachers is modified through an interpretive process used by teachers in translating curriculum materials into practice in their classrooms.

The symbolic interactionist theory of personal meaning was selected as the research orientation for the study because its conception of *meaning* and *interpretation* provide a basis for empirical study of the process of interpreting curriculum materials through which teachers construct their classroom practice. From a teacher's classroom use of curriculum materials we can infer the meanings that those materials have for him. From those meanings we may make inferences about the nature of teachers functional paradigms and how they influence interpretation of curriculum materials.

The design of the study is based on the symbolic interactionist conception of the nature of meaning. Basically, the study consists of asking selected classroom teachers about the use of a specific set of curriculum materials in their classroom. The teachers were asked to reflect on their classroom practice and to indicate how the materials were used and why they were used in this way. The data were collected by means of interviews with three high school chemistry teachers and by means of a survey questionnaire completed by a randomly selected sample of 69 high school chemistry teachers. The teachers responses were analyzed to identify factors which influenced teacher interpretation of curriculum materials, and to identify some of the relationships among those factors. Based on the data collected, a model of teacher interpretation of curriculum materials was devised.

H. Significance of the Study

The interpretation of curriculum materials by classroom teachers is an essential connection between the intentions of curriculum developers and the actual use of the materials in the classroom. An examination of the meaning that curriculum materials have for classroom teachers should lead to a better understanding of the process of translating the intended curriculum, as reflected in curriculum materials, into classroom practice. An increased understanding of the translation process will be valuable to curriculum developers, school authorities, and classroom teachers and could lead to more effective use of available resources in bringing about positive change in the schools. A thorough examination of the interpretative process used by teachers in determining the meaning of the stated curriculum should reveal some of the characteristics of this phenomenon and should contribute toward developing a theoretical basis for viewing implementation which is useful to both practioners and curriculum researchers.

I. The Organization of the Dissertation

The dissertation consists of five chapters and nine appendices which are organized in the following manner.

The background to the problem and the personal ground of the author are presented in Chapter 1. In addition, the research problem and guiding questions are stated, the key terms are defined, and the design of the study and its theoretical framework are outlined.

In Chapter 2 a review of selected literature related to the study is presented. The literature reviewed in this chapter is organized into four sections: background to the problem, background to the methodology, research on teacher decision-making, and research on science curricula in practice.

Chapter 3 deals with the design of the study. In this chapter the development of the survey instruments is described, the method of sample selection is outlined, and the data collecting procedures are discussed. The procedures used to analyze both the qualitative and quantitative data are outlined as well.

In Chapter 4 the results of the study are presented and discussed. In this chapter the findings from the classroom observations and the teacher interviews are reported, discussed, and compared. In addition, a detailed presentation and discussion of the data captured by the Chemistry Classroom Practice Survey (CCPS) is given and summarized.

The results of the investigation are summarized in Chapter 5. In this chapter the method of data collection and analysis are reviewed and the research questions which guided the study are used to summarize the data collected. The major findings of the study are presented and some recommendations for further curriculum research are given.

The appendices contain background information related to the study. Outlines of the Alberta chemistry program and the ALCHEM materials are given in Appendices A and B. Appendix C contains copies of the letters written to the superintendents and principals regarding the CCPS. Copies of the Observation Sheets, and SOS and CCPS questionnaires are presented in Appendices D, E, and F. The transcripts of the interviews with the three selected chemistry teachers are contained in Appendices G, H, and I.

II. SURVEY OF SELECTED LITERATURE

The literature reviewed in this chapter is grouped into the following four categories: background to the problem, background to the methodology, research on teacher decision-making, and research on science curricula in practice.

A. Background to the Problem

In this section the literature reviewed provides background to the problem of investigating classroom teachers' interpretations of curriculum materials. The main concepts of symbolic interactionism are presented and related to the current study, the relationship of theory and practice is examined, and the concepts of personal practical knowledge and functional paradigms are considered. In addition, recent developments in chemistry education are summarized, the Alberta high school chemistry program is outlined and critiqued, and the ALCHEM materials are described.

Symbolic Interactionism

Symbolic interactionism is an approach to the study of human group life which developed out of American pragmatism, particularly out of the thinking and writing of William James, John Dewey, Charles H. Cooley, and George H. Mead. It is Mead who is regarded as the chief architect of the theory. Mead taught at the University of Chicago from 1893 to 1931, and although he published very little of his work in this area, books and articles based on lecture notes taken by his students were published after his death in 1931. After Mead's death, Herbert G. Blumer at the University of Chicago, and Manford H. Kuhn at the University of Iowa, became the two leading exponents of the approach. Blumer coined the term, "symbolic interactionism", in a 1937 article.

Symbolic interactionism is distinguished from other approaches in psychology and sociology by the following three interrelated points (Blumer, 1969):

1. The meaning that objects have for human beings are central in their own right.
2. Meanings are creations that are formed in and through the defining activities of people as they interact.
3. The use of meanings by an individual occurs through a process of interpretation.

In contrast to other approaches in psychology and sociology, symbolic interactionism does not regard meaning as emanating from the intrinsic makeup of the object, nor does it regard meaning as arising through a coalescence of psychological elements in the person.

In symbolic interaction, the process of interpretation is regarded as proceeding in two distinct steps (Mead, 1934). First, the person has to indicate to himself the things that have meaning, through a process of communicating with himself. Second, the person selects, manipulates, and transforms the meaning in the light of situations in which he is placed and in the direction of his action, in a formative process in which meanings are used and revised as instruments for the guidance and formation of action.

The distinctive nature of human conduct is "symbolic interaction", i.e., human response is not a direct reaction to the environment or to the action of others, but is mediated by the use of socially constructed symbols. Although humans can and do respond to the action of others without interpreting that action (non-symbolic interaction), uniquely human action is based on a process of interpretation and construction of meaning. Cooperative activity is made possible through the sharing of meanings. The process of communicating shared meanings requires two things:

1. Each individual acertains the intention of the acts of others.
2. Each individual makes his own response on the basis of that intention.

Intention is interpreted through the use of "significant symbols", i.e., through language. For the symbolic interactionist language is the principal medium of social organization in human society. Mead points out that cooperative action requires a shared understanding of language. In order to engage in concerted behavior each participating individual must be able to attach the same meaning to the same gesture. There can be no cooperative action unless interacting individuals interpret gestures similarly. It is my contention that a large component of the policy/practice issue in curriculum is a matter of differing interpretation of the language used in stating the curriculum.

For Mead the nature of meaning is implicit in the structure of human interaction.

> The logical structure of meaning, . . . is to be found in the threefold relationship of gesture to adjustive response and to the resultant of the given social act. Response on the part of the second organism to the gesture of the first is the interpretation - and brings out the meaning- of that gesture, as indicating the resultant of the social act which it initiates, and in which both organisms are thus involved. This threefold or triadic relationship between gesture, adjustive response, and resultant of the social act which the gesture initiates is the basis of meaning; for the existence of meaning depends upon the fact that the adjustive response of the second organism is directed toward

> the resultant of the given social act as initiated and indicated by the gesture of the first organism. (Mead, 1934, p. 81)

Meaning is thus a development of something already there as a relation between certain phases of the social act. The threefold or triadic relation between gesture, adjustive response, and resultant of the social act which the gesture initiates constitutes the matrix within which meaning arises. Mead regarded the response of one person to the gesture of another in any given social act as the meaning of that gesture. The adjustive response of one individual to the gesture of another is the interpretation of that gesture by that individual. Thus in symbolic interactionism the meaning is given in terms of response.

In the current study, the interpretation of curriculum materials by classroom teachers is regarded as involving the relationship among three elements which correspond to the elements in Mead's triadic nature of meaning. These three elements are the following:

1. Individual components in the curriculum materials.
2. Response to that component of the curriculum materials by the classroom teacher.
3. Classroom practice initiated by that component of the curriculum materials.

The term, "component of the curriculum materials", refers to specific items in the materials such as, a laboratory exercise, an explanation of a principle, or a student exercise. In the current study it is assumed that the meaning of the curriculum materials for the classroom teacher will be revealed by what he says about his use of the materials and the reasons offered for this use.

A major weakness of the analysis of symbolic interactionism lies in its almost exclusive restriction to linguistic symbols. Other aspects of symbolic life such as, graphic design, physical appearance, manners, and ritual are ignored. Although almost every aspect of a given culture can function symbolically, symbolic interaction focuses almost exclusively on verbal communication. Since the current study focuses on teacher interpretation of printed curriculum materials and makes use of teachers' verbal and written responses to questions concerning their use of these materials, the emphasis on linguistic symbols seems appropriate.

The Relationship of Theory and Practice

The task of effectively integrating thought and action has plagued philosophers, frustrated social scientists, and stymied professional practitioners for many years (Argyris & Schon, 1974). In this section the implications of the theory / practice distinction for the current study will be examined.

The distinction made in the current study between the stated curriculum and classroom practice stems from an inherent difference between the natures of theoretical and practical knowledge. In the first of three major critiques of educational research, Schwab (1969, 1971, 1973) identifies failure to make the theory / practice distinction as the major impediment to educational progress. In Schwab's view, the aim of theoretical knowledge is to provide general statements which are extensive and durable, i.e., the universal statements provided by theoretical knowledge are intended to apply to a wide range of situations over long periods of time. Schwab maintains that the aim of practical knowledge is to aid decision-making and guide action in specific situations and that, in contrast to theoretical knowledge, practical knowlege has no great durability or extensive application.

Schwab (1969) argues that the field of curriculum inquiry cannot make a significant contribution to educational progress as long as it continues its inappropriate pursuit and application of theoretical knowledge. He maintains that the character and substance of theoretical knowledge and practical knowledge are fundamentally different because the problems they address and the methods they use are different. The central idea in Schwab's argument is that since teaching is a practical pursuit, a theoretical approach to curriculum inquiry is inappropriate. He contends that by its very nature theory cannot take into account all of the factors that must be considered in the complex decision-making involved in actual teaching and learning. He points out that many of the theories used in curriculum studies are borrowed from other fields (e.g., theories of personality and political structure) and at best apply to only one or two aspects of a specific situation. Schwab insists that the field of curriculum studies will regain its ability to contribute to the quality of education only when the energy expended in curriculum research is shifted from theoretical to practical orientations.

Although Schwab's theory/practice distinction has proved to be a useful tool for guiding educational thought, it has the unfortunate effect of arbitrarily dividing one's thinking about the wholeness of human experience. As Maslow (1966) reminds us, the customary scientific technique of dissection and reduction has serious deficiencies in studying humans and human activities. Schwab's notion of the theoretical and practical are rooted in the Aristotelian distinction between the practical and theoretical interests of mankind. In the Aristotelian view, theoretical interests lead to a pursuit of knowing and understanding things, while practical interests direct the doing and making of things. Aristotle's analytical approach permeates Western thought, and while it can be a powerful approach to understanding complex issues, it does encourage one to think of reality as being made up of separate parts rather than as an integrated wholeness (Zukav, 1978).

The philosopher, McKeon (1952) has traced the discussion of theory and practice in philosophy from antiquity to the present. McKeon describes the problem of relating theory and practice as follows:

> In their practical aspects, the relations of theory and practice present two problems--the problem of the influence of circumstances in the determination of thought, and the problem of the consequences of thought, doctrine, and philosophy in the alteration and control of circumstances. (p. 79)

He points out that in discussing the relation of theory to practice, the nature of both theory and practice are subject to many interpretations. McKeon uses the terms, *logistic, operational, problematic,* and *dialectical* to identify four ways that have historically characterized the relationship between theory and practice. Connelly (1980) has used McKeon's terms to categorize the approaches that have been taken in curriculum research over the last twenty years.

According to the *logistic* view, practice is treated as applied theory and it is assumed that the motives of action differ from the principles of knowledge. The logistic method constructs formal systems of theory on the model of mathematics. Rational solutions to practical problems are sought in applications of theory, in the way that engineering and medicine apply scientific laws in the solution of problems in construction and combatting disease. In the logistic view, practical pursuits are usually treated as action which has been motivated nonrationally. In Connelly's view, the logistic method manifests itself in curriculum research in those studies which emphasize the development of knowledge aimed at controlling the uses of theory in practice. This feature marks the attempts of educational reformers to build systems analysis theories implementation strategies, and models of planned change.

The *operational* method applies the test of concrete action by translating theories into action and seeking verification in observable results. Knowledge is viewed as activity and process, and the practical is identified with whatever can be made to work. As with the logistic method, practice is seen as basically nonrational and consequently practical knowledge is sought in opinion and in the criteria of usefulness. Unlike the logistic, where research is aimed at the development of rational, logical, methods for translating theory into practice, the operational tends to "fly by the seat of the pants". As Connelly sees it, curriculum research which lays its trust in such matters as needs assessment and user opinion to determine the attitudes and predispositions of practitioners belongs in the operational category. Operational literature is marked by frequent refences to "change agent", "modifying user attitudes", and "beliefs and values".

The *problematic* method is basically a method of resolving problems as they occur in terms of the particular issues they present. Within the problematic view, theory and practice are seen as closely related. The practical is viewed as a form of inquiry which differs somewhat from inquiry in the natural sciences. The methods of knowledge production are viewed as different from the methods of practical problem solving. Nevertheless, knowledge is viewed as entering practice through problem solving methods. The problematic method is adopted to the resolution of problems encountered in experience. According to this conception, knowledge is modified, adjusted and used selectively according to the dictates of the particular problem confronted in practical situations. Connelly regards references to "mutual adaptation" and "action research" in the curriculum literature as reflecting the problematic method.

The *dialectical* method treats theory and practice as inseparable since both consist of "reconciling contraries in dynamic organic wholes" (McKeon, p. 84). McKeon maintains that in all forms of dialectic, from Plato to Marx, action is either closely associated or completely identified with theory. Practice is regarded as theory in action and if theoretical notions and practice are incompatible, it is the theory rather than the practice that is seen to be deficient. The dialectical method consists essentially of reducing such oppositions as those found between theory and practice. Theory, according to the dialectic, is much less fixed than it is in either the logistic or operational views. and it is assumed to change and modify according to the shifting exigencies of the practical world. In Connelly's opinion, the dialectical method contrasts sharply with the attitudes of most policy makers, developers, and science education researchers whose fundamental assumption is that more and more sophisticated ways of implementation need to be developed to ensure that the intentions set by curriculum reformers are translated into practice.

Connelly maintains that educational reformers over the last twenty years have essentially been guided by a logistic conception of the relationship between theory and practice, and that operational and problematic conceptions of school reform have developed only because the logistic approach has been largely unsuccessful. In Connelly's judgement, the logistic orientation essentially discredits the practical knowledge of teachers. In his view, sophisticated in-service work is often used to indoctrinate teachers with the intentions of developers. Connelly contends that operational views frequently present ethical problems in their manipulation of teacher's practical knowledge, because the results of the needs assessment and opinion surveys are typically used to manipulate and persuade teachers through the use of rewards. Unfortunately, he does not specify the nature of these rewards nor illustrate their use. Connelly does not acknowledge the use of inservice seminars as a potential mechanism for providing feedback from classroom teachers to curriculum developers and supervisors. In Connelly's view, the problematic method has not been given an adequate test. As he sees it, the essential difficulty with the problematic is that when it is taken seriously as the solution to specific practical problems reform becomes sporadic and tends to lose continuity, as first one and then another problem arises and is solved. He points out that in the current educational reform literature of the problematic persuasion, the problems are not genuinely local, having been set by outsiders. Connelly contends that to date the dialectical method has been virtually unused by curriculum reformers, and practical needs and practical knowledge remain unrecognized. He maintains that school reformers need to elaborate dialectical methods of relating knowledge to the improvement of classroom practice.

In the current study the policy / practice issue is viewed from the "practice" side of the interface. The assumptions of symbolic interactionism are used as the basis for examining chemistry teacher's interpretation of the stated curriculum and its extention into curriculum materials. In symbolic interactionism, *meaning* and *interpretation* are central concepts. In the current study it is assumed that a chemistry teacher's use of curriculum materials will be determined by the meaning that the materials have for him, not by curriculum materials *per se*. It is also assumed that the meaning of curriculum materials for the chemistry teacher arises out of the interaction he has with others regarding them, e.g., students, colleagues, curriculum supervisors, university instructors. A third assumption is that the meaning of curriculum materials for the chemistry teacher is modified through an interpretive process used by the teacher in translating curriculum materials into practice in his classroom.

Schwab's call to revive the field of curriculum studies by shifting emphasis from theoretical to practical matters has prompted a serious re-assessment of the direction of curriculum research and has contributed to an increased emphasis on practical matters in the curriculum literature (Schubert, 1980). Connelly and Ben-Peretz (1980) have examined the role of the classroom teacher in using and doing curriculum research and curriculum development over the past two decades. In their view the overwhelming message for the role of the teacher is that of delivery agent. The more naive tendency is to regard teachers as conservative and as an impediment to school reform, while the more sophisticated tendency is to recognize the influence of teachers over the intended curriculum and to devise various implementation strategies for action-research to account for and to circumvent this influence. Connelly and Ben-Peretz contend that there are very few indications in the educational literature to indicate a commitment to the autonomy of the teacher and to the power of the inquiring teacher mind in school reform. The portrayal of the role of the teacher in the *Curriculum guide for senior high school chemistry* (Alberta Education, 1977) is consistent with Connelly's description of teacher as "delivery agent".

Roberts (1980) advances some alternative explanations for why teachers modulate curriculum materials and use them differently than the developers intended. Where there is a mismatch between what the curriculum developer had in mind and what comes to life in a teacher's classroom, Roberts suggests that it may be caused by one of the following possibilities:

1. The teacher doesn't understand or can't do what the developer suggests.
2. The teacher understands but, on the whole, does not value what the developer suggests.
3. The teacher understands and generally values what the developers suggests but, reserves the right, and takes the responsibility, to alter the developers generalized suggestions when it is in the best interests of an individual pupil to do so.

Roberts goes on to point out that the teacher must interpret the contents of curriculum materials in order to make them meaningful in his particular situation. The interpretation process is necessary whenever anyone other than the teacher develops the material, whether that is done by a multimillion dollar curriculum project or by other teachers in the same school system. Thus, the interpretive process is an essential part of implementing the intentions of curriculum developers and school authorities. Because personal interpretation seems to play a critical role in the process of translating the stated curriculum into classroom practice, it was chosen as the focus of the current study.

In arguing that neither curriculum theory nor curriculum materials can contribute directly to the improvement of science education practice, Roberts points out that the products of research studies do not refer to any actual, unique events of science education practice, but rather specify general relationships among variables. This situation arises from the fundamental difference between theory and practice. Since curriculum materials prescribe generalized conditions under which hypothetical pupils can experience science education events, it is only natural that teachers will have to modify the materials for their individual pupils in their own unique situations. In the current study it is assumed that the statements in curriculum documents and materials will have different meaning for classroom teachers than for curriculum developers and school authorities. The purpose of the current study is to identify some of these meanings and to examine the interpretive process by which they were formulated.

Personal Practical Knowledge

In discussing the role of intuition in scientific discovery, Polanyi (1957) argues that there are many contributions made to scientific thought by acts of personal judgement which cannot be replaced by the operation of explicit reasoning. He emphasizes the parts played by guesswork, intuition, and chance in scientific investigation, citing these as evidence that theoretical achievement calls into play an intellectual creativity superior to rationality alone. He contends that intuition and perception have similar structures which are based on our natural sensibilities to hidden patterns. In Polanyi's view, both intuition and perception are skills which can be developed by a process of learning. It seems likely that intuitive knowledge would play an important role in the creative process of translating the intended curriculum into classroom practice.

Based on their work in training educational administrators to initiate and lead school reform programs, Argyris and Schon (1974) have advanced the notion of *theories of action*. This term is used to describe all of an individual s propositions about the structure and operation of society as well as about the physical world. They maintain that theories of action constitute a sociology or physics of everyday life, which individuals use in their day-to-day planning, communicating, negotiating, listening, and organizing. Argyris and Schon conceptualize the task of training administrators as one of teaching them new theories of action in order to increase their effectiveness in leading school reform. They contend that the chief obstacle encountered by the administrative trainees in learning new theories of action is presented by the existing theories already held by the administrators, rather than by the difficulty of the new theories. Argyris and Schon label these existing operational theories of action which specify strategies for getting what we want (e.g., resolving conflicts, making a living, and organizing a neighborhood), as *theories-in-use*.

In their view, theories-in-use tend to be tacit structures which contain assuptions about self, others, and environment. Inherent in the concept of tacit knowledge is the notion that we know more than we can tell, e.g., when we demonstrate a skill for which we cannot state an explicit program, or when we recognize one face from thousands without being able to say how we do it. They maintain that theories in use exist for professional practitioners even if they cannot state them. They maintain that theories-in-use are distinct from *espoused* theories which people use to describe and justify behavior. This distinction is important in educational research as it relates to the difference between asking a teacher about his methods, as opposed to actually observing them. Asking a teacher about his classroom practice will give information about his espoused theories, while classroom observation will give information about theories-in-use. In the current study, classroom observations and focused interviews were both used to obtain information which would reflect the meaning ascribed to the stated curriculum by classroom teachers and to gain clues about the interpretive processes used by them.

While allowing that theory can be a useful and powerful tool in curriculum studies, Connelly and Elbaz (1980) strongly advocate shifting the focus of research to the teacher and the act of teaching. Connelly and Elbaz go on to make a case for studying teachers practical knowledge. They maintain that teachers practical knowledge is most usefully viewed as "a body of knowledge held in a uniquely practical way and structured in terms of the teacher's practical purposes." (p. 113) Drawing on a recent case study done by Elbaz (1980) they outline five orientations which seem to structure the practical knowledge of one particular teacher: to situations, to theory, to others (social), to self (personal), and to experience. Each of these orientations seem to have three levels of organization, which are identified by the following terms: rules of practice, practical principles, and images. Connelly and Elbaz give the following explanation of the three terms. Rules of practice are statements, sometimes highly descriptive, of what the teacher does. The use of rules of practice is a methodical carrying out of the teacher's purposes, which may or may not be articulated. The practical principle is a broader, more inclusive, statement than the rule, embodying purposes in a deliberate and reflective way. The statement of a principle enunciates, or at least implies, the rationale which emerges at the end of a process of deliberation on a problem. Finally, the image is a brief, descriptive, and sometimes metaphoric statement which captures some essential feature of the teacher's perception of himself, his teaching, his situation in the classroom, or his subject matter. Images serve to guide the teacher's thinking and to organize knowledge in the relevant area. The images are generally imbued with a judgement of value and constitutes a guide to the intuitive realization of the teacher's purpose. Connelly and Elbaz emphasize that the structure of a teacher's practical knowledge is likely to be unique.

While it seems likely that the content and organization of a teacher's practical knowledge is unique to that individual, it also seems likely that there would be common elements in the practical knowledge of a group of teachers. The existence of common elements in teachers' practical knowledge might account for the sense of identification that one teacher feels when reading case histories of the work and thinking of other teachers.

Building on the work of Connelly and Elbaz, Connelly and Clandinin (1982) have advanced the concept of *personal practical knowledge*. In their view, the metaphors, images, rules, and principles which guide a teacher's classroom practice are all part of his personal practical knowledge. Connelly and Clandinin (1982) describe the conception of personal practical knowledge in the context of an ongoing, detailed case study of an inner city school in Toronto:

> Our accounts and understanding of the expressions of personal knowledge in the minded practices of schools: its rhythms, such as those contained in the movement from kindergarten to grade 12; from September to June; and from opening bell to dismissal at day's end; its rituals such as those contained in opening exercises, staff meetings and the stating of individual and school philosophies; its habitual actions expressed in subject-matter organization, marking, testing, seating and question asking techniques, are shaped by this focus on personal knowledge. So to is our more modest interest in other minded practices contained in the making of curriculum materials, kits, units, displays and reports to parents and officials. (p. 2)

Clandinin (1983) has used data collected in this case study as the basis of her Ph. D. dissertation, which is a conceptualization of images as a component of teacher personal practical knowledge.

Since personal practical knowledge has been defined to include every conceivable facet of a teacher's knowledge which could influence his day-to-day teaching, it will clearly play an important role in the translation of the intended curriculum into classroom practice. However, the notion of personal practical knowledge is not conceptualized clearly enough to guide either the data gathering or data analysis for the current study. To date, the work of Connelly and his associates has focused on developing the conceptualization of teachers' personal practical knowledge, rather than on using the concept in curriculum research. As the conceptualization of personal practical knowledge is further developed, it promises to be a valuable construct for guiding studies of why classrooms function as they do.

Functional Paradigms

As a means of analyzing organizational change, Imershein (1977) has extended the notion of paradigms and paradigm shifts used by Kuhn (1970) in his study of scientific practices. Building on Imershein's work, Crocker has advanced the concept of a *functional paradigm*, as a means of investigating why classrooms function as they do. The notion teachers' functional paradigms seems particularly well suited to the examination of chemistry teachers' interpretation of curriculum materials undertaken in the current study.

In his book, *The structure of scientific revolutions*, Kuhn uses the term, "paradigm", in two distinct senses.

> On the one hand, it stands for the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community. On the other, it denotes one sort of element in that constellation, the concrete puzzle-solution which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science. (p. 175)

Imershein (1977) bases his reformulation of the paradigm concept on three major points in Kuhn's analysis of the development of science.

1. In learning about scientific research, a student is introduced to a common set of practices, instrumentations, and research questions provided by the current paradigm, rather than by learning a set of rules or abstract theories to be applied in research.
2. The specification and origin of scientific activities is paradigm specific. That is, both the nature of the research and the means of carrying it out are bound up in the paradigm itself.
3. The revolutionary shifts from one paradigm to another, which characterize the development of science, involve changes in ways of thinking, of seeing the world, and of doing research.

Imershein argues that organizational change may be considered analogous to scientific change, and that the activities of the organizational members may be seen as paradigm guided in a manner similar to scientific activities. He advocates extending the paradigm concept to organizational change as a means of directing greater attention toward the content and structure of of knowledge used by organizational participants, and as an alternative model for understanding organizational action.

In extending Imershein's ideas to education, Crocker (1983) has proposed that research on teaching be directed to identifying the functional paradigms of teaching.

> Following Imershein's line of argument, it is assumed that teachers are, indeed, similar to other communities of scholars or practitioners in that they share common goals, problems, exemplars, routines, etc. which constitute a "functional paradigm". The use of the term "functional paradigm" is meant to convey the idea that the characteristics which unite a community of practioners is likely to be centered on practical matters.

Crocker's concept of a functional paradigm is analogous to the concept of theories-in-use advanced by Argyris and Schon (1974). Using the functional paradigm concept, the problem of teaching educators new theories of action becomes a matter of effecting a paradigm shift.

Crocker maintains that the curriculum implementation is a 'strategic site' for examining the functional paradigms of teachers, since such paradigms are likely to be more apparent under conditions of change. He suggests that the frequently noted resistance of teachers to curriculum change may be the result of the innovation challenging the prevailing functional paradigms of the teachers.

As Crocker points out, identifying functional paradigms involves seeking commonalities among teachers rather than differences, since a paradigm is viewed as that which unites a community of scholars (Kuhn, 1970). The notion of common elements in teachers' practical knowledge runs counter to some recent research in the area. Based on his study of what teachers do and think, Lortie (1975) concluded that teachers do not see themselves as sharing, "a viable, generalized body of knowledge and practice (p. 79)". According to Lortie, the craft of teaching is, "marked by the absence of concrete models for emulation, unclear lines of influence, multiple and controversial criteria, ambiguity about assessment timing, and instability in the end product (p. 136)." Based on their in-depth case study of one teacher, Connelly and Elbaz (1980) maintain that the structure of a teacher's practical knowledge is likely to be unique. Perhaps the current study will shed some light on the extent to which teachers' beliefs, values, and techniques are commonly held, and the extent to which they are idiosyncratic, as they apply to interpreting curriculum materials.

Curriculum Development in High School Chemistry

During the last twenty-five years there have been major shifts in emphasis in high school chemistry curriculum materials. Prior to 1960, high school chemistry curricula placed a heavy emphasis on applied and descriptive chemistry. Curriculum materials written before 1960 typically focused on a study of industrial processes (e.g., Solvay process, manufacture of sulfuric acid) and the preparation, properties, and uses of common chemicals (e.g., hydrochloric acid, acetylene).

The chemistry curriculum materials developed during the nineteen-sixties (e.g., CHEM Study, CBA), downplayed applied and descriptive chemistry in favor of a heavy emphasis on major theoretical concepts and principles (e.g., collision theory, equilibrium) and the process of scientific thinking. Fensham (1981) describes curriculum materials which emphasize the major concepts of science and the structure of knowledge, as "head science". He contends that the reason such courses appeal to only a small percentage of students is that people are not as interested in "thinking through" science as they are in having science "do something for them".

In the nineteen-seventies, curriculum materials such as, *Action Chemistry* and *Interdisciplinary Approach to Chemistry* (IAC), were developed to appeal to a larger proportion of high school students. Fensham describes this type of curriculum material with its pleasure-oriented approach lacking rigor or structure as "heart science". He contends that these materials have not had a significant impact on the majority of students.

Since 1980 there have been numerous appeals to chemistry educators to return to a systematic presentation of applied and descriptive chemistry (Baslo, 1980; Coombes, Lazonby, & Waddington, 1983; Webb, Last, & Rayner-Canham, 1983). These appeals usually advocate inclusion of socio-economic and environmental aspects of science and a greater emphasis on industrial topics. One aspect of emphasizing applied chemistry is to focus curriculum materials on more regional concerns than when theoretical chemistry is emphasized. In his call for a program which would teach "hands science", Fensham has called for a chemistry curriculum which would emphasize the work that chemists do: making compounds, identifying substances, modifying substances, and inhibiting or facilitating reactions. He maintains that such a course would appeal to large numbers of students and would provide a solid basis in chemistry knowledge for both those who plan careers in science and those who do not.

Nelson (1983) contends that the underlying cause of the current debate in chemistry education, concerning appropriate emphases in high school curriculum materials, stems from an underlying differences in conceptions about the nature of chemistry. He maintains that chemistry curricula should reflect a view of chemistry that includes both the *pure* and *applied* branches of the field.

> Chemistry is a much broader subject than the one that is currently being taught in schools and universities, majoring as it does on 'pure' chemistry and 'rational' theory. I believe that those of us who are responsible for the teaching of chemistry should try to enlarge the conception of the subject, and to deal with aspects of it that we are presently tending to neglect. (Nelson, 1983, p. 125)

Most of the recent ideas concerning high school chemistry curricula are reflected in the descriptions of the Alberta high school chemistry program and ALCHEM materials which follow.

The Alberta Chemistry Program

Since the Alberta high school chemistry program forms the basis of the current study a brief outline of the program is given here. The place of the *Curriculum guide for senior high school chemistry (1977)* among other curriculum policy documents is described, and its contents are outlined and critiqued.

In the area of curriculum, the *School Act* (Alberta, 1982) gives the Minister of Education the authority and responsibility to prescribe courses of study and instructional materials for grades 1 to 12 in the schools of Alberta. Background information, general guidelines, and specific regulations concerning curriculum are transmitted from the Minister of Education to school administrators and teachers through a series of curriculum policy documents. We shall limit ourselves here to a brief discription the relevant aspects of those documents which pertain to chemistry education. The *Junior-senior high school handbook 1982-83* (Alberta, 1982) begins with a statement of the goals of basic education for Alberta, which are divided into goals of schooling and goals of education (seen as shared with the community). The general objectives of science education are listed at the beginning of the science section. The handbook also outlines the numbering system for senior high school academic courses (10, 20, 30), and the time/credit relationship (25 hours per credit). The academic science courses are established as shown in Table 1.

To some extent the dissatisfaction with the CHEM Study program, which led to the development of ALCHEM, may have been caused by differences between the organization of the CHEM Study materials and the intended Alberta high school chemistry program as set out in the curriculum guide. The CHEM Study materials had been designed as a one year course, usually taught at the grade eleven level in the United States, while the Alberta chemistry program covers three years, commencing in grade 10. In Alberta a half course (62.5 hours) in chemistry is offered in each of grades 10 and 11, and a full course (125 hours) is offered at the grade 12 level.

The goals of basic education and general objectives of science education are repeated in the *Program of studies for senior high schools 1978* (Alberta Education, 1978). In addition, the program of studies lists objectives for each of the senior high school science courses, and outlines the core/elective format of the courses. For Chemistry 10 and 20, the program of studies indicates that approximately 40 hours of instructional time shall be devoted to the core topics and about 25 hours to elective topics, while in Chemistry 30 the time breakdown is to be 75 hours and 45 hours, respectively. In all three chemistry courses the content of the elective units is to relate to the core in one of three ways:

1. an extensive study of a core topic (breadth).
2. an in-depth, intensive study of a core topic (depth).
3. a practical application of a core topic.

The *Curriculum guide for senior high school chemistry (1977)*, repeats the objectives of secondary school science and the outline of Chemistry 10, 20, and 30 from the program of studies as well as listing overall objectives for the high school chemistry program, outlining core topics, and presenting some views on the teaching of chemistry. A list of the "Objectives of High School Chemistry", as presented in the chemistry curriculum guide, is contained in Appendix A along with an outline of the core topics for Chemistry 10, 20, and 30. Since the chemistry curriculum guide is the document which classroom teachers deal with most directly, and since it defines the stated curriculum for the current study, it will be examined here in some detail.

Table 1

Alberta Senior High School Academic Science Courses

Biology	Chemistry	Physics	Time	Credits
Biol 10	Chem 10	Phys 10	62.5 h	3 cr
Biol 20	Chem 20	Phys 20	62.5 h	3 cr
Biol 30	Chem 30	Phys 30	125 h	5 cr

Close examination of the chemistry curriculum guide reveals a particular perspective of each of four essential aspects of curriculum: the subject, the student, the teacher, and the community. The introduction to the guide contains three statements which suggest a broad view of chemistry as a human endeavor:

> . . . Chemistry is considered to be a basic science integrating much of man's understanding of nature . . .
> . . . Chemistry (is) a lively, interesting and important part of the scientific adventure which involves, in one way or another, the whole spectrum of society.
> . . . Chemistry has developed in a very human way with a history of frustration, enlightenment, revision and practical application. Not only have there been aspects of past development but they are very evident in the Chemistry of the present. (p. 5)

The last statement pictures chemistry as a constantly evolving body of knowledge. A reference to the "tentativeness of chemical theory" (p. 3) in one of the objectives of high school chemistry also suggests that our understanding is constantly developing. Chemistry is also seen as a disciplined pursuit of knowledge which uses definite methods and approaches. The following are listed as examples of the "methods used by chemists" (p. 3):

> 1.1 processes in scientific inquiry: observing, hypothesizing, classifying, experimenting, and interpreting data.
> 1.2 skills in the cognitive, affective, and psychomotor domains.
> 1.3 skills in individual and group problem solving. (p. 3)

Although chemistry theory is seen as constantly developing, there is no reference to "scientific revolutions" (Kuhn, 1970).

Some of the objectives of high school chemistry speak of students' acquiring a knowledge of applied chemistry and an understanding of certain current issues which involve chemistry. These references suggest that chemistry is a body of knowledge that has power to illuminate our understanding of both the physical and social world. It also suggests that chemistry is implicated in some serious social problems:

> 3.1 use and depletion of natural resources
> 3.2 chemistry of environmental pollution
> 3.3 use and misuse of chemicals such as preservatives, additives, insecticides, etc. (p. 3)

The sinister side of chemistry is referred to again when suggestions for reducing, "the possibility of accidents and the potential hostility of the chemical laboratory" (p. 11) are listed in the section on laboratory safety.

The curriculum guide seems to view students as a group of individuals who possess a wide range of abilities and interests. "A significant portion of the high school population," is seen as capable of benefiting from the study of chemistry. This view contrasts with that in most other places in North America where chemistry is regarded as an elitist course for the top 20% of the student body. The chemistry program is, "intended to appeal to a wide segment of the student population" (p. 8), who are seen as capable of, "serious study and diligent work" (p. 8).

Students are viewed as being in a process of mental development and the study of chemistry is regarded as an effective means of developing their minds. Students' work in the laboratory is seen as most effective in this regard:

> The laboratory must function to provide the student with the required skills for the generation of knowledge. These skills are vital to the student because of new problems he will be asked to answer and areas of knowledge that will come into existence during his lifetime. (p. 9)

The individuality of students is acknowledged as teachers are admonished to select "teaching activities to match the learning styles of the students." In the list of factors to be considered in selecting elective modules, student interest is placed above the interests and expertise of the teacher.

The curriculum guide states that the teacher should be, "a designer of educational encounters" (p. 10), rather than a dispenser of information. Several suggestions are given as to how the teacher can plan for, organize, and present learning experiences for students. The emphasis in these suggestions is on lab work and class discussions. Most of the ideas are given as practices that *should* be followed, but teachers are told that they *must* maintain a balance, "between theory and application and between inductive and deductive thought processes". There is generally a condescending tone in the section on the teaching of chemistry. For example, teachers are informed that, "students can read faster than the average teacher can speak" (p. 10).

A disparaging account of traditional chemistry teaching is given and the implication is that the pattern described is the mode:

> The lecture has been used primarily to disseminate information. Students have been expected to take notes on the material "covered" in class and to reproduce that material on tests. Very little opportunity has been given for the frank and open discussion of problems which require knowledge of chemistry and research skills to arrive at viable solutions. (p. 9)

The guide mentions that, "the function of dispensing information by the teacher is being replaced" (p. 10), without acknowledging the role of classroom teachers in developing new methods and materials. Only once, in the entire document, is there a reference to "the professional judgement of the teacher" (p. 14).

The curriculum guide views communities as being varied and as demanding variation in instructional patterns. The elective part of the chemistry program is designed to address this variation in interest, thus enabling the study of a local chemical industry or chemically related problems. The following is listed as one of the advantages of the core-elective format:

> Local interests, facilities, and expertise can be brought into the chemistry program very easily. (p. 13)

This suggests that the community could have some direct input into the chemistry program of the local school.

According to the curriculum guide the intent of the high school chemisty program is to produce scientific literacy in high school students by having them acquire certain knowledge and develop certain skills. "Acquire" and "develop" are only two verbs used in stating the objectives of high school chemistry. There is a peculiarity in the wording of the objectives. Under the heading, "Objectives of High School Chemistry," are listed objectives that *students* should "strive to achieve." Presumably, the chemistry program is designed to enable the student to meet these objectives, but that is not stated. There seems to be a certain sleight of hand in moving from what should be a statement of program objectives to a statement of student objectives.

According to the guide, the intent of the chemistry program is to present:

> A highly diversified program emphasizing direct physical experiences reinforced by the use of print and non-print materials and discussion . . . (p. 8)
> Chemistry as a lively, interesting and important part of the scientific adventure which involves, in one way or another, the whole spectrum of society. (p. 5)

In addition, the guide stresses the importances of presenting the, "interrelationships among the different sciences and mathematics" (p. 3) and counteracting the impression, "that science has become too specialized" (p. 3)

The objectives of the individual Chemistry 10, 20, and 30 courses parallel the objectives of the high school chemistry program, but they are stated in narrower, more specific terms. For example, the high school chemistry objective 6, that students should:

> Acquire a knowledge and appreciation of the history and philosophy of chemistry. (p. 4)

becomes the Chemistry 10 objective, 10.6, that students should:

> Know the contributions made by various scientific investigators to the topics being studied. (p. 17)

In general, the individual chemistry course objectives focus on specific content and skills which are more readily tested than the general objectives of the chemistry program. The implication here is that, in practice, teachers are not expected to spend much time on objectives dealing with the nature of science.

In the section on the teaching of chemistry, the curriculum guide denigrates the concept of a single text book as a course of studies:

> No text, manual, or single aid will provide a creative and appealing approach to instruction for everyone. (p. 8)

Instead, the guide advises, students should be given problems for consideration which are presented in a variety of ways: demonstrations, films, film loops, and lab activities. Teachers are encouraged to draw applications of chemistry theory from the students' daily experience.

The choice of core references, *Keys to Chemistry* or *ALCHEM* at the 10 and 20 level, and *Chemistry: Experiments and Principles* or *ALCHEM* at the 30 level seems consistent with the approach recommended in the curriculum guide. All three references provide numerous applications of chemical principles and all emphasize lab work. However, each of these references attempts to be a complete program and teachers generally choose between one or the other. Although the guide explains that a choice of reference material will help teachers deal with the range of student abilities, it does not explain how this will help a teacher cope with the range of abilities within a given class. For economic reasons, the choice of primary reference is usually made on a class basis, or more often, on a school or system basis.

The elective modules provide a means of addressing the particular interests and abilities of a given class. Unfortunately experience has shown that the prescribed core material for Chemistry 10 and 20 takes up all the allotted time. The guide cautions against usurping "some of the time allotted to elective modules to cover the "more important core material" (p. 14). Most teachers have found, however, that teaching to even a minimum level of mastery of the Chemistry 10 and 20 core requires all of the 62.5 hours allotted for the course. Classroom experience seems to indicate that only those classes which are specially selected for their academic ability are able to complete the core in time to study electives at the Chemistry 10 and 20 levels.

The curriculum guide states that chemistry teaching should "involve the student to the maximum extent with the concepts of chemistry" (p. 9), and that the student should "participate actively in the search for knowledge" (p. 9). Student participation is to be encouraged in the classroom by discussions of problems which require knowledge of chemistry theory and research skills to arrive at viable solutions. It is interesting to note that, although the tentativeness of chemical theory is acknowledged, there is no provision for discussing the validity or completeness of current chemical theory. The implication is that chemical theory is able to solve a multitude of practical and social problems. Students are expected to become involved in collecting and organizing information, and up to 40% of class time is recommended for lab activities.

Of the five curriculum orientations identified by Eisner and Vallance (1974), *academic rationalism* and the *cognitive processes* approach are the most dominant in the curriculum guide. The influence of academic rationalism can be seen in the several objectives which emphasize teaching the fundamental ideas of chemistry, the traditional methods used by chemists, and the history and philosophy of chemistry. One of the reasons the guide gives for doing lab work in high school is to, "provide answers to traditional problems that have been accepted as being worthy of answering" (p. 9). This sounds very much like the method of training future scientists in the prevailing paradigms which Kuhn (1970) describes. The emphasis that the guide places on the development of process skills and problem solving strategies reflects the cognitive processes approach. One of the benefits of studying chemistry is seen to be the development of problem solving skills that will last the student throughout life. Objective 1.1 lists specific process skills that students are to develop, and teachers are encouraged to borrow freely from process oriented materials.

The ALCHEM Program

An account of the development of ALCHEM is given in a paper by Jenkins and Kass (1980). Since the ALCHEM materials are an integral part of both the stated curriculum and classroom practice as they are defined in the current study, the materials are described briefly here and outlined in more detail in Appendix B.

The ALCHEM materials were written with the objectives of the Alberta chemistry program in mind, and a close match between ALCHEM materials and the Alberta chemistry program is evident in the section of the curriculum guide which references the objectives to the prescribed textbooks. The original stated objectives of the ALCHEM project were:

1. make the materials easy to learn from
2. maintain a high level of chemistry
3. integrate applied and descriptive chemistry into all aspects of the course

These objectives are reflected in both the content and format of the ALCHEM materials, which are unique in a least three ways:

1. Applied and descriptive chemistry are used to develop chemistry theory.
2. Several of the current concerns in science education are addressed, including the nature of science, science and society, and practical versus theoretical knowledge in science.

3. The three student core books consist of pages which can be inserted into student loose leaf binders. Each core book contains the following features: statements of behavioral objectives, explanations of chemical concepts and principles, information about the sources and uses of chemicals, student exercises, sample solutions, outlines for teacher demonstrations, laboratory exercises, and a special edition of the periodic table.

An instructional design analysis of the ALCHEM material was conducted in 1981, as a joint project of the Manitoba Department of Education and the Educational Products Information Exchange Institute (EPIE). The EPIE analysis indicated a high degree of congruence between the stated intentions of the program and the content of the materials.

> The content arrangement is logical and sequential. Core units emphasize content and bring in applied and descriptive chemistry wherever possible. (EPIE, 1981, p. 3)

The analysis also found that the materials were compatable with the intention stated in the ALCHEM Teachers' Guide (Jenkins et al, 1976), that the materials were written to provide for maximum flexibility of teaching styles.

> Methodology congruence is high. Materials provide for a variety of classroom activities and offer a high degree of flexibility in teaching styles. Activities are congruent with the verification and discovery approach. Teacher selection of materials is necessary owing to the large number of possible activities and optional exercises. Teacher preparation is minimal because of the detailed nature of the classroom activities. (EPIE, 1981, p.4)

Some of the unique features of ALCHEM mentioned above were noted in the science textbook analysis which was part of a recent study of science education in Canadian schools sponsored by the Science Council of Canada (Orpwood & Souque, 1984). ALCHEM was rated as fairly or completely adequate with respect to both "readability for students" and "Canadian examples" by 93% of the respondents, while 79% gave that rating to "appropriateness of science content to grade level", "relationship of text's objectives to your own priorities", and "accounts of the application of science". In the detailed analysis, ALCHEM was mentioned as the only text which explictly mentions both "applied science" and the "Canadian context". Teacher use of the ALCHEM materials would seem to be an ideal situation for investigating the role of teachers' functional paradigms in translating curriculum materials into classroom practice. The materials were specifically written to match the objectives of the Alberta chemistry program and they, "offer a high degree of flexibility in teaching styles" (EPIE, 1981, p. 4).

B. Background to the Methodology

The literature surveyed in this section is background to the methodology used in the study. Three basic research orientations are described, the concepts of validity and reliablity are discussed as they relate to qualitative and quantitative research, and the methods used in some recent studies of science classroom practice are reviewed.

Research Orientations

In recent educational literature the merits of different research orientations has become a matter of debate. Drawing on the ideas of Habermas (1972), Aoki (1978) has outlined three approaches to curriculum research. First, there is the *empirical analytic* orientation which seeks explanatory and technical knowledge by using the research mode commonly known as "science". Second, there is the *situational interpretive* orientation in which research is conceived as the search for the meaning given to an object or occurence by the people in a situation. These accounts are called phenomenological description. Third, there is the *critical theoretic* orientation which has emerged recently in the curriculum research literature. Researchers within this orientation are concerned with critical understanding of fundamental interests, values, assumptions, and implications for human social action.

In McCutcheon's (1981) view, the three approaches to curriculum inquiry can be seen as forming the vertices of a triangle. In her scheme, a specific study can be placed along one of the sides or within the triangle, by the degree to which it reveals the assumptions and principles underlying each of the three approaches or blends them together. Distinctions can be made among the approaches by the methods they employ, the questions they address, and the assumptions they make regarding issues such as generalizibility and objectivity versus subjectivity.

McCutcheon illustrates the difference in the three approaches by considering how researchers of each persuasion might approach a study of 42-minute class periods.

> A positivist studying this situation might wonder how to increase teachers effectiveness, and thereby student achievement, in the 42-minute periods, perhaps by measuring students time on task and correlating that with achievement test scores. A phenomenologist might wonder what meaning 42-minute periods have for participants. A critical scientist might wonder about the origin of 42-minute periods and how such time affects students experience, rendering disciplines accessible to some and inaccessible to other students, thereby reproducing society so that the able remain able and the weak remain weak. (p. 6)

As can be seen from McCutcheon's example, the research methodology or methodologies appropriate for a study will depend upon the questions asked by the researcher.

Rist (1982) maintains that the "hegemony" of the empirical analytic approach to inquiry has dissolved as researchers have come to recognize that there are multiple routes and multiple destinations for their efforts, and that the idea, "what cannot be measured cannot be important" (p. 439), is a fallacy. In Rist's view, qualitative research encompasses all of the following approaches: ethnographic research, field work, ethnography, field studies, naturalistic studies, and case study methodology. Rist's use of the term, "qualitative research", is synonomous with Aoki's term, "situational interpretive", and McCutcheon's use of "phenomenology". In comparing qualitative and quantitative research orientations, Rist contends that qualitative research uses holistic, inductive approaches which emphasize validity in capturing our understanding of the world. He maintains that by contrast, quantitative research uses deductive approaches which emphasize reliability to focus on some component of the world. While Rist's description of qualitative and quantitative research is generally accurate, he has clearly over-simplified the relative emphasis on validity and reliablity in the two approaches. While quantitative research does concern itself with reliablity, it is just as much concerned with validity as is qualitative research.

In discussing the place of qualitative research in science education, (Roberts (1981) argues that,

> . . . the strong points of quantitative and qualitative research methodologies provide complementary information for constructing a more adequate picture than one would have from either alone (p. 27).

Robert's view is consistent with Rist's contention that qualitative and quantitative research approaches are not mutually exclusive. Rist stresses that the lack of synthesis between the two approaches does not mean that they cannot be used in conjunction with one another.

The views expressed by Roberts and Rist support the approach that was used in the current study, which began with a qualitative approach involving observations and interviews with three teachers and continued with a quantitative approach using survey techniques. In this way the strong points of both qualitative and quantitative research were used to provide complementary data on the interpretive processes used by teachers in translating the stated curriculum into practice in their own classrooms. Since both approaches are used in the study, a discussion of the meaning of validity and reliablity in the context of both qualitative and quantitative research will be undertaken here.

Validity and Reliablity in Educational Research

In assessing the quality of educational research, questions of validity and reliability are of central importance, regardless of whether quantitative or qualitative methodologies are used. The concepts of *validity* and *reliability* have been thoroughly discussed and carefully defined in the context of quantitative research, but their meaning in the context of qualitative research is still in a formative stage. In the following section, the meaning of the terms, *validity* and *reliablity* will be examined in the context of both quantitative and qualitative research.

In quantitative research *validity* refers to, "the accuracy with which a set of test scores measures what it ought to measure"; while *reliablity* refers to, "the consistency with which a set of test scores measures whatever it does measure" (Ebel, 1972, p.435). Validity would seem to be the primary consideration, since we must first establish that we are measuring what we wish to measure before determining whether our measuring device gives consistent values. Although reliability is an important quality in an instrument, it cannot supplant validity, since instruments may dependably measure behavior other than that intended. Campbell and Stanley (1963) make a distinction between *internal* and *external* validity. Internal validity refers to correctly attributing causality, while external validity is associated with the generalizability of the findings to other settings. Bracht and Glass (1968) have expanded the concept of external validity by developing the notions of *population* validity and *ecological* validity. Population validity is concerned with determining what population of subjects can be expected to behave in the same way as did the experimental subjects, while ecological validity refers to the conditions under which the same results can be expected.

Although some kinds of validity are not usually considered quantifiable, others lend themselves to numerical estimation. Ebel (1972) has classified these two types of validity as being, respectively, *direct* and *indirect*, while Thorndike and Hagen (1961) refer to them as being dependent on *professional judgement* and *rational analysis*. Face validity and content validity require professional judgement, while concurrent, predictive, and construct validity are amenable to rational analysis or numerical estimation.

Face validity has been variously defined as the appearance of reasonableness of a test (Thorndike & Hagen, 1961), or "what the test appears to measure" (Ebel, 1972). Thorndike and Hagen point out that what a test looks like may be of importance in determining its acceptability to those writing it. Content validation rests essentially on authorities' judgement of the representativeness of the sampling of the universe in which the investigator is interested, the universe itself being as clearly defined as possible (Cronbach & Meehl, 1967). Even though the content of the universe to be tested may have been defined, Kerlinger (1973) cautioned that the items of a test must be studied and each item weighed for its presumed representativeness of the universe and its presumed relevance to the property being measured. Ebel (1972) insisted that the directions for administering and scoring the test should be subjected to logical analysis and expert judgement, as should the rationale and specifications for the instrument. In Ebel's view, content validity can be assumed only after all these judgemental assurances of validity have been received. Face and content validity are both important considerations in the current study, where questionnaires are used to gather data on teachers' classroom practice and students' opinions of curriculum materials. It is important that the items in the questionnaire be representative of and relevant to the question of teacher interpretation of curriculum materials. It is also important that the items appear to the respondents as being relevant to the stated purpose of the questionnaire.

Two measures of validity which are estimated empirically are concurrent and predictive validity. Both of these are established by the degree of consistency which a test has with a criterion measure, usually expressed by a correlation coefficient (Cronbach & Meehl, 1967). Differentiation between concurrent and predictive validity is primarily on the basis of time, concurrent being established by comparison of the instrument with the criterion at the same time, and predictive validity with a criterion measure in the future. The greatest difficulty in criterion-related validity is with the criterion (Kerlinger, 1973). Thorndike and Hagen (1961) identified four desirable qualities in a criterion measure, the first being that the measure be relevant. Since relevancy is not measureable, it is still necessary to rely on professional judgement to provide the appraisal of the degree to which any partial criterion measure is relevant to the ultimate criterion. A criterion measure should also be free from bias, providing equal scoring opportunities for all persons. The third quality the criterion measure should have is reliability, that is, being stable or reproducible. Finally, the criterion measure should meet the practical considerations of convenience and availablity. In the current study the criterion measure is the actual classroom practice of the teachers who were surveyed. Although a qualitative assessment of classroom practice is provided by classroom observations for the three teachers who were interviewed, it is not available for the 69 teachers who responded to the classroom practice survey. Thus, for most of the data in the current study, it will not be possible to give numerical estimates of the concurrent or predictive validity.

Construct validity is a third measure of validity which can be estimated empirically. In construct validity the focus is on measured construct rather than the measuring instrument (Cronbach & Meehl, 1967). The measured construct is taken to be some postulated attribute which is assumed to be reflected in test performance. Of concern primarily in the field of psychology, construct validation is used when no criterion measure of a construct exists. For example, in the current study the construct validity of the Chemistry Classroom Practice Survey questionnaire could be estimated by factor analysis of the teachers' responses to those items which involve using Likert ratings scales.

Although some validation procedures yield numerical values, a great deal of subjective judgement is involved in interpreting these numbers and assessing their meaning for a particular purpose. The guidelines for interpreting numerical assessment of validity are well established in quantitative research, but as Roberts (1981) points out:

> . . . someone had to establish them and whole generations of researchers have had to come to trust them, share the metaphysical presuppositions behind them, and learn how to use them in making arguments based on data. (p. 30; emphasis in the original)

Clearly, subjective judgement is an essential aspect of assessing the validity of both qualitative and quantitative research.

Some concerns have been raised about the validity and generalizability of the findings taken from case studies which use a situational interpretive approach. In a paper discussing the validity of quantitative inquiry, Dawson (1979) observes that getting the subjects to confirm or disconfirm the observations is a direct and effective way of establishing the validity of an observation. This approach also provides an opportunity for the researcher to discuss the meaning of a situation with the student or teacher. Stake (1978) responds to the concern about the generalizablity of case studies by arguing that case studies will often be the preferred method of research because they may be epistemologically in harmony with the readers experience and thus to that person a natural basis for generalization. In Stake s opinion the appropriateness of the case study approach depends on the purpose of the research.

> When explanation, propositional knowledge, and law are the aims of an inquiry, the case study will often be at a disadvantage. When the aims are understanding, extension of experience, and increase in conviction in that which is known, the disadvantage disappears. (p. 6)

In the context of qualitative research, Dawson (1979) has conteptualized validity as, "the adequacy of a description as a representation of a social situation" (p. 1). Dawson points out that since 'adequacy' implies purpose, validity is associated with purpose or utility in this conceptualization. Valid knowledge is taken to be knowledge which is of value for a given purpose. Since studies typically have multiple purposes, a given study will have a different validity for different aspects of the study. Although Dawson s conceptualization of validity is clearly not quantifiable, it is consistent with Cronbach's (1971) views of the validity of test instruments.

> One validates, not a test, but an interpretation of data arising from a specified procedure. A single instrument is used in many different ways - Smith s reading test may be used to screen applicants for professional training, to plan remedial instruction in reading, to measure the effectiveness of an instructional program, etc. Since each application is based on a different interpretation, the evidence that justifies one application may have little relevance to the next. Because every interpretation has its own degree of validity, one can never reach the simple conclusion that a particular test "is valid". (p. 447; emphasis in the original)

Within the context of qualitative research, validity concerns are frequently directed to developing strategies to confirm or disconfirm findings. Some investigators who use qualitative aproaches take the view that researchers should attempt to confirm or falsify their findings themselves. Becker (1969) has developed procedures for coding and analyzing field notes, by compiling frequencies of the observation of the phenomenon. The observations are categorized according to whether the observations were statements or activities and according to the circumstances under which they were made. In this way, both the researcher and the research audience have a basis for judging the amount of confidence to place in the research conclusions. Douglas (1976) has developed an approach which he calls, "investigative social research", which takes the basic position that people are evasive or dishonest with researchers. In Douglas's view, information should be continuously "tested out" using the following approach:

1. Comparing a supposed fact, member account, etc. with the most reliable ideas and generally patterned facts that the researcher has from his prior experience.
2. comparing one's own ideas and inferences with the observed facts in a setting.

Some researchers (Lindesmith, 1968; Denzin, 1970) have developed the concept of "analytic induction", a research procedure for developing, refining, and accumulating evidence in support of a universal causal hypothesis until no negative examples can be identified. Another confirmation strategy which has been used by qualitative researchers is to ask participant in the situation under study to react to the investigator's perceptions and interpretations, confirming or disconfirming them (McDonald & Walker, 1974). Although the perceptions of participants are not necessarily more accurate than those of the researcher, the validity of data which are challenged by participants should be examined carefully (Dawson, 1979). This method of validity assessment seems appropriate for the current study where the three classroom teachers could be asked to read and evaluate written interpretations of the observations made in their classrooms and of the interviews with them.

Triangulation, in which data bearing on a issue is gathered from multiple sources, frequently used by qualitative researchers (Denzin, 1970; Dawson, 1979). Stake and Easley (1978) aimed at a range of methods, although they recount difficulties in preserving some features of the original design, primarily as a consequence of the reluctance of their observers to utilize certain more structured data gathering techniques. Triangulation would seem to be a useful and appropriate means of validity assessment for the current study where data concerning teacher interpretation of curriculum materials are being collected from a variety of sources.

A number of strategies have been suggested to enhance internal validity in qualitative research. Shatzman and Strauss (1973), among others, emphasize the importance of researcher-participant relations. Dean and Whyte (1969) suggest that the confidence that develops in a relationship over a period of time is the best guarantee of spontaneity, and hence validity. Dean and Whyte provide the following guidelines for enhancing the validity of data gained from observations and interviews.

1. The influence of ulterior motives can sometimes be quashed by pointing out that the researcher is in no position to influence the situation in any way.
2. Bars to spontaneity can usually be reduced by assurances to the informant that his remarks are confidential and will be reported to no one else.
3. The interviewer should not express, or indicate in any way, his disapproval of statements made by the informants or indicate any of his own values that might intrude in the situation.
4. It is a good precaution to ask questions in many different ways so that the complex configurations that a person s sentiments represents can be more accurately understood.

Clearly, a large measure of trust is required by both researcher and participant, if communication is to be effective.

After examining the "plethora" of validity concepts found in both qualitative and quantitative research literature, Brinberg and McGrath (1982) suggest that there are three underlying meanings in the concept of validity. They maintain that validity may be viewed as *value*, as *correspondence*, and as *robustness*. In their view, validity as *value* is principally as a pre-study concern.

> Deciding what elements and relations to sample from the substantive domain, for example, implies deciding what aspects of that domain will be regarded as real and important events and processes. Similarly, for the methodological domain and for the conceptual domain, sampling implies deciding what elements and relations will be regarded as important and legitimate. In all three cases, applying criteria and standards to decide what elements and relations are regarded as real implies applying a set of values to such selections. These

> values are validity-like, but they are neither correspondence or robustness. (p. 19)

The idea of *correspondence* is central in measures of internal validity where correspondence between two sets of things is considered, for example, a set of concepts and a set of observations, or two sets of measures of a single phenomenon. The correspondence theme underlies those forms of validity which are of interest during the research process, such as construct and predictive validity.

Validity as *robustness* seems to be central to the various forms of external validity, such as ecological and population validity, which are considered after the research process. Brinberg and McGrath regard explanatory validity as an aspect of external validity.

> For research . . . in which a body of data is built and then explained, the key problem facing the investigator has to do with how the chosen concepts account for the study findings. That is, the investigator must explore whether there are alternative, equally plausible, conceptual explanations for the findings. (p. 18)

Explanatory validity is an important concern in the current study where data on teacher use of curriculum materials is gathered and then explained in terms of teacher interpretation of those materials.

While validity is indicated by agreement among independent methods of assessment, reliablity is indicated by agreement among similar methods of assessment separated by time and location. Reliability is dependent upon agreement between two maximally similar methods of measuring some trait (Campbell & Fiske, 1967). Methods of obtaining repeated measures estimates include the following: repetition of the same test, administration of a second equivalent form of the test, subdivision of the test into two or more equivalent fractions, averaging all possible split-halves, and rating performances by two or more judges (Cronbach, 1960; Thorndike & Hagen, 1961). Both the formula for and the method of establishing reliability are dependent upon the nature of the test and the research design, and must be selected accordingly. Deutscher (1966) contends that although interviewer and observer reliability are important concerns in social science research, certain other types of reliability are inappropriate.

> The notion of test-retest or any other "reliability" measure involving a time

> sequence is antithetical to social science since it must make the incorrect assumption that human thought and behavior is static and, therefore, that any change in response is a reflection of either instrument error or deception. In fact, such recorded changes are more likely to reflect shifts in attitude or behavior on the part of the respondent. (p. 241)

In quantitative educational research, "data" is associated with numerical results of measurement operations such as test scores and frequency counts. Roberts (1981) points out that once reduced to numerical form, it is easy to forget that such data is an attempt to describe, unambiguously, a particular construct. In quantitative research, one is continually faced with trade-offs. Consistency and reproducibility, free from any possibility of subject bias on the part of a marker can be obtained by the use of standardized multiple choice tests. In doing so, however, one must accept that scores obtained from such an instrument may not adequately measure complex understanding. An alternative approach is to utilize free response questions, and rely on the ability of an expert judge, or panel of judges, in assessing a score. Subjective bias then becomes an issue. In qualitative work, data is frequently generated by interviews and protocol analysis, and by guided observation using a prepared checklist. This presents a parallel problem in reliability.

Several different techniques are used to control reliability problems in qualitative research. One consideration is the skill level of the researcher. Our confidence of the reliablity of qualitative researcher is certain to be affected by our subjective assessment of the capabilities of the researcher. A degree of objectivity will be obtained by the practice of reporting lengthy protocols verbatim in research reports. In this way, the reader can, to some extent, form his own conclusion about the researcher's method and interpretation. The problem presented by selection remains, however, since the reader does not know what the researcher has chosen to include as affirmation of his position, and what he has omitted. This may be a problem which is parallel to instrument choice in quantitative research, but in quantitative research the research community has a clearer idea of what has been passed over.

Deutscher (1966) points out a problematic aspect of survey research, such as the CCPS which is part of the current study.

> Our scientific conclusions, for the most part, are based on analysis of verbal responses to questions put by an interviewer. Those responses may be

> written or oral and the questions may range from forced choice to open ended, but the fact remains that what we obtain from such methods are statements of attitude, opinion, norms, values, anticipation, or recall.
> . . . the assumption must be made that verbal responses reflect behavioral tendencies.
> This inferential jump from verbal behavior to overt behavior appears to be tenuous under some conditions. (p. 235)

Deutscher contends that regardless of the theoretical orientation taken, researchers have no reason to expect to find congruence between attitudes and action and every reason to find discrepancies between them.

Deutscher uses the conceptual framework and behavioral theory outlined by Blumer (1966) to consider, from a symbolic interactionist perspective, the apparent validity problem inherent in using verbal behavior to gain information about overt behavior.

> It is possible that the conceptual problem can be broached by viewing verbal behavior and overt behavior as different segments of a single act in process. Apparent inconsistencies can then be conceptualized as resulting from errors in interpretation on the part of the actor or from re-interpretation of the meaning of the act during the interval between the moment of verbal expression and the moment of overt behavior. This formulation also sensitizes the investigator to the possibility that the apparent inconsistency is a result of the actor's perception of the verbalization and the overt behavior as segments of two different acts, i.e., regardless of the investigator's intent, the word and the deed may be perceived by the actor as relating to two different objects. (p. 243)

Symbolic interactionists insist that humans act, either verbally or overtly, in response to the symbolic meaning the confronting object has for them in the given situation. A question directed to a teacher in an interview forces him to respond to the words and to the interviewer; while standing face to face with a class of high school chemistry students forces him to respond to a very different set of symbols. Given the tenuous connection between verbal behavior and overt behavior, inference about actual classroom practice made from responses to interview questions and survey questionnaire items must be done with caution. Inferences about how classroom teachers interpret curriculum materials, however, can be made validly from both of these sources of information since they give information about espoused theories (Argyris & Schon, 1974). Direct classroom observations, on the other hand, give information about theories-in-use.

Research Methodologies Used in Studies of Classroom Practice

The fifteen implementation studies reviewed by Fullan and Pomfret (1977) involved a wide range of data gathering techniques, including classroom observation, survey questionnaires, focused interviews, and document analysis. In commenting on the methods used in the studies that they reviewed, Fullan and Pomfret suggest that classroom observations can provide the most thorough assessment of classroom practice. However, they do express some concerns about using classroom observers to gather data on teacher use of curriculum materials:

1. The presence of observers may affect the quality of the teacher's performance.
2. Some dimensions of implementation are more difficult to assess than others. Observation methods may describe the mechanical use of an innovation, but not adequately assess other dimensions such as understanding the philosophy of the innovation.
3. The use of observation methods is expensive and often not feasible if large samples are involved.

Fullan and Pomfret point out that questionnaires are much cheaper than observational methods and could be a substitute for them. They do not acknowledge that the nature of the information received from questionnaires could be quite different from that obtained from observation. In the terminology of Argyris and Schon (1974), classroom observations will give information about theories-in-use, while interviews and questionnaires will give information on espoused theories.

Fullan and Pomfret regard the focused interview as having considerable merit in determining the nature and forms of teacher use of curriculum materials. While information from questionnaires is limited by the questions which must be set in advance, interview methods allow moving beyond the original questions as the interview develops and allow for probing interviewees for clarification of initial answers. In addition, the interview format allows for clarifying the intent of the original question if it becomes apparent that it was misunderstood. One of the limitations of questionnaires is that the researcher does not know if the terminology used in the questions has the same meaning for the respondent as for the researcher. Fullan and Pomfret suggest that data from interviews can be content analyzed to determine the nature and extent of modulation of curriculum materials by a particular teacher. This approach seems particularly well suited to studies of mutual adaptation which recognize that teachers will adapt new approaches and material to suit their own situation.

They suggest that both document analysis and focused interviews are promising techniques because they allow more thorough assessment than questionnaires but are not as time consuming as observation methods. In the current study questionnaires were used to gain information about the classroom practice of 69 teachers, while observations, document analysis, and focused interviews are used to gain a more thorough assessment of three teachers and their teaching situations.

In summarizing their review of measurement techniques used in implementation studies, Fullan and Pomfret make three general observations. First, it is probably desirable to employ more than one method in any given situation, given the advantages and disadvantages of the different methods and the different information that may be uncovered, as well as the opportunity for cross-validation. Second, some dimensions of implementation can be directly observed (e.g., use of materials, changes in structure and in behavior), while others can only be inferred (e.g., knowledge and understanding) or determined through questioning and examination of documents. Finally, there is no intrinsic reason why any of the methods cannot be used with either the fidelity or the mutual adaption approach. Fullan and Pomfret's recommendations support the methodology used in gathering the data for the current study, where focused teacher interviews were supplemented by classroom observation and study of teacher developed materials (e.g., supplementary notes, labs, demonstrations, and examinations).

A major weakness of many implementation studies seems to be that they measure the degree of implementation without revealing why some aspects of an innovation are adopted while others are ignored. This weakness is particularly severe in strict empirical studies which reduce the observations to average ratings and percentage scores. The numbers represent generalized data on a limited set of variables and do not aid the understanding of a particular classroom situation. Aoki (1978) contends that the major weakness of empirical studies (which tend to be one-dimensional) is that the uniqueness and messiness of any lived situation tends to be "reduced out". It seems clear that more than one approach is necessary to gain an understanding of the interpretive process used by chemistry teachers in translating the stated curriculum into classroom practice. For this reason the current study used both qualitative and quantitative methods to obtain complementary data.

Shavelson and Stern (1981) have reviewed research done during the nineteen-seventies on teachers' pedagogical thoughts, judgments, decisions, and behavior. Their review assesses both the substantive and methodological progress made in this area of educational research, and identifies areas of research needed to improve the practice of teaching. Of the methodologies they reviewed, policy-capturing and stimulated recall are of interest to the current study. In a policy-capturing study, teachers are given descriptions of hypothetical situations. These scenarios are comprised of a combination of factors, which are systematically manipulated from one description to another. The teachers are required to make judgments about some aspect of the scenario and to indicate their judgment on an interval scale. Their judgements are regressed on the characteristics of the situation and the resulting multiple regression equation is taken as a model of the teachers' decision-making process. In particular, the relative weights of various factors in the teachers' strategy for decision-making can be assessed. A practical problem associated with the policy-capturing methodology is that a large sample is required in order to have enough responses for each of the combinations of factors in order to make the data analysis meaningful. Another problem associated with this approach is that of generalizability, since teachers responses to hypothetical situations may not be an accurate indicator of how they would respond in real life situations (Deutscher, 1966). Because of the large sample size required and the problems of generalizability, a policy-capturing instrument was not used in the current study.

In stimulated recall the reseacher either audiotapes or videotapes the lesson. The tape is then played back to the teacher to stimulate his recall of the covert mental processes that accompanied the teaching activities in the lesson. This process assumes that teachers are willing and able to recall their thought processes. In the current study, points noted during the classroom observations served a similar function in stimulating teacher reflection during the subsequent interiews.

C. Research on Teacher Decision-Making

Curriculum Implementation

Interest in studying teacher decision-making grew out of the curriculum implementation literature of the nineteen-sixties and seventies. In his book, *The meaning of educational change*, Fullan (1982) maintains that one of the most serious mistakes in the North American curriculum reform movement of the nineteen-sixties and seventies was the naive assumption that involving some teachers on curriculum committees or in program development would facilitate implementation because it would increase acceptance by other teachers. As far as most teachers were concerned, a change was just as much externally experienced when it was produced by fellow teachers as when it came from university or government agencies. Fullan contends that it could be even more aggravating if the teachers who had developed the change saw themselves as innovative and their colleagues as somewhat resistant or slow to pick up on the great new materials they had produced.

My own experience with the development and implementation of the ALCHEM program certainly bears out Fullan's contention. In the process of developing the materials, the ALCHEM authors became quite enthuiastic about some of the innovative approaches that had been developed. It was often found, however, that classroom teachers did not appreciate the new approach, but preferred their old ways. For example, as a way of teaching students the importance of chemistry in daily life, a use is stated for every chemical substance and chemical reaction mentioned in the ALCHEM materials. For many teachers the background information was extraneous material which distracted from the theoretical chemistry in the course, so they instructed their students to ignore it.

In summarizing the numerous curriculum implementation studies which he reviewed, Fullan (1982) contends that teachers use three main criteria in deciding whether to put their efforts into a particular change:

1. Does the change potentially address a need? Will students be interested? Will they learn?
2. How clear is the change in terms of what the teacher will have to do?
3. How will it affect the teacher personally in terms of time, energy, new skill, sense of

excitement and competence, and interference with existing priorities?

In Fullan's view, change is a highly personal experience, and each teacher who will be affected by a curriculum change must have an opportunity to work through this experience in a way in which the rewards at least equal the cost. Fullan maintains that the principal reason that so few curriculum innovations take root in the schools, is that those who advocate and develop changes get more rewards than costs, and those who are expected to implement them get more costs than rewards.

Fullan stresses the "primacy of personal contact" in summarizing the factors which are associated with successful curriculum change, i.e., situations in which the classroom practice accurately reflected the intentions of the developers. At the teacher level, the degree of change is strongly related to the extent to which teachers interact with each other, as well as with personnel providing technical assistance. At the school level, collegiality among teachers, as measured by the frequency of communication, mutual support and help is a strong indicator of an implementation's success. Fullan explains the importance of personal contact in determining the success of curriculum implementation by his theory of change:

> Significant educational change consists of changes in beliefs, teaching style, and materials which can only come about through a process of personal development in a context of socialization. (p. 121)

Connelly (1980) would likely regard Fullan's statement as an endorsement of the sophisticated in-service work typically used by logistically oriented educational reformers to indoctrinate teachers with the intentions of developers. Connelly maintains that the logistic viewpoint essentially discredits the practical knowledge of teachers.

One might also account for the primacy of personal contact by considering the opportunity it provides for classroom teachers and curriculum specialists to develop a shared meaning of the statements in the curriculum documents and materials. This view assumes that the meanings held by all the involved parties; classroom teachers, curriculum developers, and school authorities, are all seen as legitimate and capable of growth and development. This view of implementation is expressed lucidly by Werner (1980):

> Ideally, implementation as a minimum includes shared understanding among participants concerning the implied presuppositions, values and assumptions which underlie a program, for if participants understand these, then they have a

> basis for rejecting, accepting or modifying a program in terms of their own school, community and class situations. To state the aim another way, implementation is an ongoing construction of a shared reality among group members through their interaction with one another within the program. (pp. 62-63)

Fullan contends that, "the key to school improvement is to recognize that meaning is the central issue, and to do things that will enhance this meaning" (p. 295; emphasis in the original). He maintains that the lack of shared meaning is the primary cause of the failure of implementation.

> The main reason for failure is simple - the developers went through a process of acquiring their meaning of the new curriculum. And once it was presented to teachers, there was no provision for allowing them to work out the meaning for themselves of the changes before them. Innovations which have been succeeding have been doing so because they combine good ideas with good implementation support systems. (p. 103; emphasis in the original)

Fullan's individualistic theory of meaning is consistent with the symbolic interactionist view of meaning which guides the current study. When a classroom teacher fails to do what a curriculum developer intends, it does not necessarily mean that he rejects the idea. He may be doing what he has interpreted the stated curriculum to mean. This is not to say that the classroom teacher's interpretation is less worthy than that of the curriculum developer or school authority, but his interpretation is different because meaning is context bound.

Curriculum Decision-Making

Empirical studies of teacher curriculum decision-making began in the nineteen seventies as an outgrowth of curriculum implementation research. In reviewing these studies, Leithwood, Ross, & Montegomery (1982) found that these investigations have focused on two main areas:

1. Identifying the influences which shape the decision making process and its outcomes.
2. Determining the range of issues considered by teachers in their decision-making.

The studies designed to identify the most salient influences on teacher decision-making suggest that the teachers' own experience and opinion of student behavior are the major influences. The principal and other teachers in the school are a significant but generally less important influence which varies widely and seems to depend on the particular task and the extent of collegial interaction. The investigations designed to determine the range of issues spanned by teachers curriculum decision-making have focused on the autonomy of the classroom teacher in the areas of instruction and classroom management. Leithwood et al summarize the findings of these investigations as follows:

1. The individual teacher is virtually autonomous in determining:
    A. the nature of teacher-student (and to a lesser extent student-student) classroom interaction.
    B. the kinds of classroom activities students will engage in to achieve curriculum outcomes.
    C. the pace timing, and total time allocation of instruction for a given curriculum area.
    D. the frequency and timing of testing.
2. Teachers share decision-making responsibilities with others in areas of
    A. objectives.
    B. choice of curriculum material.
    C. choice of teaching strategies.
3. Principals and staff groups dominate classroom decisions about
    A. global concepts and the basic outline of the curriculum,
    B. the criteria to be used in assessing the curriculum and the students.

The foregoing generalizations are based on fifteen years of research on curriculum decision-making which runs across all grades and subject areas. The empirical studies of teachers curriculum decisions consistently identify factors emanating from the classroom as having the greatest influence on teachers. Rayder and Body (1978) have advanced the concept of *psychological proximity* as a basis of predicting the relative strength of potential influences on teacher decision-making. Using this concept, the dominant influence of students on teachers' decisions stems from their position as the direct, persistent audience of the classroom teacher's behavior. Wahlstrom, Regan, and Jones (1982) have conducted an investigation designed to determine the relative influence of teacher beliefs on classroom teachers' practice in evaluating students in junior high school English, mathematics, science, history, and geography. They suggest that their results are consistent with Rayder and Body s hypothesis that as behavior becomes less socially visible the effect of social support on teachers classroom practice will decrease.

MacDonald and Leithwood (1982) conducted a study designed to identify reasons offered by teachers for their classroom curriculum decisions and to relate these reasons to a pattern of teacher needs. Their research was guided by the following three questions:

1. What basic needs do teachers attempt to fulfil through their classroom curriculum work?
2. How do they go about trying to fulfil these needs?
3. What aspects of their professional world do they perceive to be most (and least) helpful in fulfilling these needs?

Data from their study suggest an interdependent pattern of relationships among needs which has at its core an overriding need for achievement, defined in terms of assisting students to become more cognitively competent. Because teachers recognize that there are student characteristics outside of their control which influence the extent and nature of competence possible, the criteria for success vary on the basis of the teacher's perception of the student's potential.

MacDonald and Leithwood maintain that with achievement as the core need and student cognitive growth as the sole criterion of success, teachers require reliable sources of information about the effectiveness of their classroom practice in meeting the criterion. Information is required on a short-term basis so that classroom practice can be continuously adjusted to maximize the probability of success. Data from MacDonald and Leithwood's study indicate that teachers consider spontaneous cues from students during the course of the lesson as the most direct and sensitive form of feedback about the extent of achievement. At the curriculum planning stage, trusted peer colleagues may be of value in increasing the changes of teacher success by providing reactions to a teacher's instruction where they have observed it or by indicating the probable values of proposed teaching strategies on the basis of their own direct experience. Since feedback on the effectiveness of teaching strategies, depends of good working relationships, teachers place a high value on developing good rapport with both students and colleagues. Standardized tests are viewed as sometimes useful sources of confirmation about student progress. MacDonald and Leithwood suggest that, an identified influence on curriculum decision-making can be viewed as either an instrument for the fulfilment of achievement need or as a potential source of information about the extent to which the achievement need is being fulfilled. Low-ranked influences are those perceived by teachers as relatively insignificant for either purpose.

Decision-Making in the Science Classroom

Brauer (1981) investigated the nature and scope of teacher decision-making in the implementation, adaptation, and creation of curriculum materials for the Alberta Chemistry 20 course. In an attempt to secure complementary information, a mailed survey questionnaire and a schedule of teacher interviews were used. The questionnaire was designed to obtain information on the teachers and their teaching situation, as well as to gather information on the nature and extent of teachers' decision-making in the context of Chemistry 20. The teacher interviews were designed to probe the reasons behind teachers' curricular decisions. Sixty-one survey questionnaires were analyzed and three teachers were interviewed. Brauer found that in general, the Chemistry 20 teachers in the study felt unrestricted in translating the intended curriculum into classroom practice. In fact, there was some feeling among teachers that they had more control over classroom practice than they desired. Brauer found that the teachers' own value system and conception of curriculum influenced the nature and extent of modulation of the intended curriculum more than the specific teaching situation. In general, teachers emphasized the universal, discipline oriented, cognitive concepts in both the core and elective parts of the program. Teachers were found to rely heavily on the prescribed core references and their own interests and experiences when adapting the intended curriculum to their own situation. Curriculum decision-making was found to be more influenced by the size of the Chemistry 20 staff in the teachers' school than by the professional background of the teacher. Brauer's study is closely related to the current study, in both substance and methodology. By expanding the survey and making greater use of teacher interviews, the current study attempts to investigate more closely the reasons behind teachers' curriculum decisions in the context of the complete Chemistry 10, 20, and 30 program.

Aikenhead (1983) has used a case study analysis of five science teachers in the science department of a Western Canadian high school to investigate the decisions that science teachers make as they plan for instruction. Aikenhead's data were collected over a four-month period in the autumn of 1982. By combining classroom observations and teacher interviews he probed into the personal reasons, beliefs, and dilemmas underlying science teachers' planning decisions. Aikenhead used a "thematic analysis" approach (Rist, 1982) to analyze his observation notes and interview transcripts, combing the data for common teacher concerns and patterns of decision-making.

Aikenhead found that teachers' personal experiences at university were more important in shaping their perception of academic work than were the degrees that they had earned. A teachers' personal conception of academic work was found to have a major influence in the decisions that he made as he planned for instruction. He found that, although these decisions served different purposes (personal, curricular, and social) and were somewhat different for each teacher, they had a common structure involving trade-offs and compromises. Aikenhead contends that teachers' planning decisions represented the end result of a conflict between a network of ideas about students and a cluster of teacher intentions. Aikenhead's study suggests that teachers make their planning decisions holistically within a framework which integrates science content and practical classroom knowledge, using a knowledge system which includes the basic beliefs of a teacher and the socialization of students. The knowledge system that Aikenhead describes sounds very much like what Crocker (1983) calls a "functional paradigm".

In the current study an observation/interview methodology similar to Aikenhead's was used with three chemistry teachers working in different schools. Also, a thematic analysis approach was used in analyzing the observation and interview data from the current study to search for patterns in the teachers' interpretation of curriculum materials.

D. Science Curricula in Practice

Within the last twenty years numerous studies of science curricula as translated into classroom practice have been reported. Studies done in the late sixties and early seventies focused on comparing classroom practice with the intentions of curriculum developers (i.e., the "fidelity approach"). For example, Gallager (1966) studied the classroom presentation of six BSCS teachers who were using the same curriculum materials and found a wide range of teaching styles, none of which were consistent with the philosophy of the curriculum developers. After reviewing reports of teacher behavior within specific curricula, Rosenshine (1970) concluded that the variation in classroom practice among teachers was too great to allow treating individual curricula as single instructional variables. Herron (1971) examined the conception of inquiry held by biology (BSCS), chemistry (CBA and CHEM Study), and physics (PSSC), and found that the teachers views were largely inconsistent with the stated inquiry goal of these curricula and were only marginally different from those of untrained teachers. Allen (1973) studied the process skills of third grade children and found that only five percent of the variance in student achievement could be attributed to curriculum materials.

After reviewing two decades of science curriculum development, Welch (1979) comments that the curriculum developments which dominated the attention of the science education profession for twenty years have demonstrated that the resources of the science profession can be marshalled and directed toward a perceived problem in the schools. However, Welch maintains that these curriculum developments have also demonstrated that the education system is extremely stable and efforts to change it have little effect, and that curriculum effects account for very little of the variance in student learning. Welch summarizes the results of these curriculum developments as follows:

> While there may be new books on the shelves and clever gadgets in the storage cabinets, the day-to-day operation of the class remains largely unchanged. A teacher tells his or her students what is important to learn and so the class progresses. (p. 303)

Welch seems unduly pessimistic about the possiblity of bringing about a positive change in classroom practice. Earlier in the same paper, Welch reported several positive outcomes from curriculum innovations in science curricula which were revealed by curriculum evaluations done during the sixties and seventies. For example, when compared with students in traditional courses, students in newer science programs generally showed greater understanding of the processes of science, more developed skills related to the scientific method, a slightly more positive attitude toward science, slightly more developed skills in problem solving and critical thinking.

National Science Foundation Studies

In 1977 a national survey of science, mathematics and social studies education was conducted by the Research Triangle Institute under contract to the National Science Foundation (NSF) (Weiss, 1978). This massive project included analyzing questionnaires from over 8000 individuals involved in science education in the USA. The study sought answers to the following questions:

1. What science courses are currently offered in schools?
2. What curriculum materials, equipment, and sources of information are currently used by science teachers?
3. By grade level, how much time is spent on teaching science, and what guidelines exist for establishing minimum standards?
4. What teaching methods are used by science teachers?
5. What problems are perceived by science teachers?

One of the findings of the study was that the use of NSF developed materials and approaches was not widespread at the classroom level, although most of the jurisdictions surveyed considered that these programs had been implemented. The results of the NSF study point out the fallacy of the assumption often made by school authorities, that once curriculum materials have been authorized for use and purchased by the school system, they are being used in the classroom in the way that the developers intended. Since the primary purpose of the NSF study was to gather data on the nature and extent of science programs across the United States, it did not investigate teachers' reasons for choosing the curriclum materials that they did, or the way that teachers used the materials in their daily classroom instruction.

Stake and Easley (1978) headed a team of educational researchers from the University of Illinois who gathered data about science, mathematics, and social science education in American public schools during the 1976-77 school year. The study was funded by the National Science Foundation (NSF) and was designed to provide information for shaping future programs of the Foundation. The Stake and Easley study is of interest here because it illustrates how qualitative and quantitative approaches can be combined to obtain a more complete picture of classroom practice than would be obtained if only one approach were used.

In the Stake and Easley investigation, eleven high schools and their feeder schools were selected for study. Care was taken to ensure that a wide variety of geographic, deomographic, social, and economic situations were represented. The field researchers were instructed to find out what was actually happening in the schools and what administrators, teachers, students, and parents thought was important in science programs. The field observers spent from four to fifteen weeks on site, gathering data. The observations of the case studies were supplemented by surveying a stratified random sample of 4000 educators, parents, and students with survey questions based on the field observations. After analyzing the data from their study, Stake and Easley concluded that the science classroom of today is little different from one of twenty years ago. It is not clear how they know what science classrooms were like twenty years ago, because there was no parallel previous study to use for comparison.

In summarizing their case studies, Stake and Easley describe the great extent to which socialization values influenced teacher planning. In Aikenhead's (1983) view, one of the most important ideas to emerge from the Stake and Easley case studies was the hypothesis that what teachers do with subject matter is determined by how it sustains and protects them in the social system of the school. Aikenhead observes that the expectations of society place demands on teachers to instill in students the customs and mores of the community, and to prepare them for the next level of schooling. He concurs with Stake and Easley's contention that science knowledge is transformed in the schools into a means of meeting the socialization demands of the school system, and gives the example of science content being used to promote a teacher's image of competence, to maintain student respect, and to require students to work hard.

British Columbia Science Assessment

In 1978 the Ministry of Education in British Columbia funded a wide ranging assessment of the science program in British Columbia (Hobbs and Erickson, 1980). The study used an empirical analytical approach which included administering science achievement tests to nearly all the public school students in grades 4, 8, and 12. In addition, a sample of elementary and secondary science teachers were asked to complete a questionnaire on various aspects of the teaching of science, and an instrument designed to measure attitudes toward science and scientists was administered to a sample of grade 7, 9, and 11 students.

The part of the British Columbia science assessment which has most relevance to the current study is the section on instructional practices. According to the results of the teacher questionnaire the principal form of instruction in British Columbia science classrooms involves students carrying out lab work from printed instructions, writing up the reports and submitting them to the teacher for marking. Teachers indicated that students were rarely required to make up their own laboratory experiments or to do them at home. One interesting outcome of the study was that teachers reported doing experimental work with their classes more frequently than did the sample of students. Examination of the survey instrument used indicates that the frequency was indicated by having respondents select from a list of words such as "rarely", "occasionally", and "frequently". The differing interpretation of the meaning of these words by students and teachers likely accounts for the discrepancy. Senior secondary teachers reported lecturing and giving notes more often than did junior secondary teachers. Unfortunately, the rigidity of the empirical research design did not permit probing the teachers to find out *why* these teaching methods were used.

Primary Science Project Study

Crocker (1979) used a variety of research methods to investigate the impact of the Primary Science Project (PSP) on the program and teaching practice of selected elementary schools in Queensland, Australia. Crocker's study is pertinent here because it illustrates how a combination of qualitative and quantitative methods can be used to obtain complementary information, and how information on teachers' curriculum decisions can be interpreted using the concept of a functional paradigm. The PSP had been initiated in 1975 in an attempt to improve the quality of science teaching within the bounds of the existing syllabus. The project evolved into a full scale curriculum development project which produced a source book of activities, a scope and sequence chart, and a guidelines document. At the time of Crocker's (1979) study, work had begun on collecting and writing science activities as part of the project.

The purpose of Crocker's study was to assess the impact of the Project to date and to suggest possible ways its impact might be increased. Crocker drew a sample of 20 schools out of the 40 in a particular region that had been represented at district inservice seminars. To provide a baseline for comparison, an additional 10 schools were selected from another region which had no contact with the PSP. Crocker conducted each interview in accordance with a schedule of questions that he had prepared. The questions dealt with seminar follow-up, school decisions, classroom practices, teacher understanding of some of the basic ideas advocated in the seminars, and teacher opinions on a number of science teaching issues. The questions were designed to yield open-ended responses, and probing questions were used in most cases following the the initial response. Each interview was recorded on audio tape, and in addition brief notes were made on the responses. The notes were intended to reduce the burden of a complete analysis of the tapes, and to provide preliminary summary phrases that could be useful in classifying responses. In addition to the interview, a survey instrument was prepared and administered to a sample of 430 teachers. The instruments described different situations into which the PSP was to be implemented. Teachers were asked to indicate the probability of implementation under the conditions described in the vignette. A third aspect of the study involved direct observation of a sample of 20 classes drawn from the original interview sample.

Crocker found that the impact of the PSP varied widely among teachers, with most teachers regarding themselves as free to conduct the program as they saw fit. It appeared that teachers did not feel compelled to teach science in any particular way, in spite of the existence of guidelines, consultants, project staff, and inspectors, all concerned with the teachers' activities. Unfortunately, the design of the study did not allow direct assessment of the relationship between teacher training and classroom practice. However, the data suggest that subsequent school experience and the teachers own viewpoint of science are more significant determinants of classroom practice than teacher training.

Crocker found that there was considerable teacher opposition to the discovery learning approach stressed in the syllabus and authorized curriculum materials. Teacher objections were based on concerns about classroom management, discipline, and control, and on a belief that most students are unable to operate without direct teacher guidance. This opposition led many teachers to modulate the recommended teaching strategies to a form consistent with their own philosophy of classroom management. Crocker interprets his findings as an indication that a concern with content coverage, management, and clarity in the curriculum mandate were elements in the functional paradigm of these teachers, as was the belief that students must be subject to direct instruction in order to learn. Since Crocker s data were collected from Australian elementary school teachers, they may not be generalizable to Canadian high school chemistry teachers. Using a methodology similar to Crocker s, the current study asks questions about the use of ALCHEM in Alberta which parallel the questions asked by Crocker about the use of PSP in Queensland.

Science Council of Canada Study

In October 1979, the Science Council of Canada initiated a study of Science Education in Canada, with the following three-fold purpose:

1. To establish a documented basis for describing the present purposes and general characteristics of science teaching in Canadian schools.
2. To conduct an historical analysis of science education in Canada.
3. To stimulate active deliberation concerning future options for science education in Canada.

While the study comes within the purview of the Science Council's mandate to assess the scientific and technological resources and requirements of Canada and to increase public awareness of them, the impetus for conducting the study at this time came from recent criticisms of policies and programs in elementary and secondary school science.

Since determining the history and current state of science teaching in Canada requires a variety of inquiry modes and since questions about future directions require deliberation, the term *deliberative inquiry* was coined to describe the research strategy used in the Science Council study (Orpwood, Souque, & Ferguson, 1983). The concept of deliberative inquiry is derived from the curriculum writings of Schwab (1978) and is intended to convey a sense of dialectical tension between the practical deliberations of policy makers and the theoretical inquiries of researchers. From the point of view of determining new directions for action, deliberation is the more important process with inquiry supporting and informing the deliberative process. The deliberative inquiry component of the Science Council of Canada study is unique in curriculum research, and promises to be an effective means of interfacing policy and practice. The deliberative phase of the Science Council study resulted in a number of recommendations for science education in Canada. If these recommendation are to be sucessfully implemented, the functional paradigms of teachers will need to be understood and taken into account. The deliberative process may be an effective way of doing this.

The inquiry component of the Science Council study involved the following four major projects:

1. an analysis of science curriculum policies (Orpwood & Souque, 1984).
2. an analysis of science textbooks (Orpwood & Souque, 1984).
3. a survey of science teachers (Orpwood & Alam, 1984).
4. eight case studies of science teaching (Olson & Russell, 1984).

A brief outline of each section of the study and its relevance to the current study follows.

Analysis of curriculum policy documents for senior high school science courses indicate that there are five general objectives which are common to nearly every province and territory in Canada (Orpwood & Souque, 1984).

1. To teach students the basic concepts in science in a way that will enable them to understand and manipulate scientific information.
2. To develop skill in the methods and tools of science.
3. To promote an understanding of the relationship between science and society.
4. To teach students about the nature of science and its value as a way of learning and communicating about the self, the environment, and the universe.
5. To prepare students to take advantage of career opportunities in technology, industry, commerce, and business.

Apparently, the objectives of the Alberta chemistry program, outlined in Appendix A and discussed earlier in this chapter, are quite typical of the stated curricula for senior high school science programs across Canada. Orpwood and Souque point out that although Canadian science curriculum policy documents rarely give explicit statements on *how* science is to be taught, they have a major influence on classroom practice by approving textbooks. Ministry guidelines typically prescribe the content of science courses by listing topics and authorizing textbooks. This finding supports the position taken in the current study: curriculum materials are the chief means by which the intentions of curriculum developers and school authorities are communicated to classroom teachers. Thus, teacher interpretation of curriculum materials is an essential link between the stated curriculum and classroom practice.

The textbook analysis was conducted in two phases. In the first phase a stratified random sample of science teachers was asked to rate ten aspects of the textbooks they were using, if any. The teachers' responses indicated that 90% of senior high school science teachers rely on textbooks to support their classroom instruction. From the responses of 1927 teachers, a list of the most commonly used science textbooks in Canada was compiled, and for the second phase of the study 34 books were selected from the list for detailed analysis. Orpwood and Souque report that the textbooks analyzed generally conform rather well to the official objectives of science education, which supports the position taken in the current study: that curriculum materials can be considered as extensions of the curriculum as stated in policy documents.

The survey instrument used in the Science Council Study (Orpwood & Alam, 1984) was designed to gather background information about Canadian science teachers and their schools and communities, as well as teacher opinions about the aims of science education, curriculum resources, and student abilities and interests. Ideas for the general format and some of the specific items in the CCPS questionnaire were taken from the survey instrument used in the Science Council study. Consequently, it is possible to compare some of the data collected in the current study with that of the Science Council study, thus providing a form of reliability check. The survey sample was stratified by geographical area and grade level, and included 6865 teachers and 1227 schools. The school was the unit of selection and all science teachers within a selected school was asked to complete and return the questionnaire. The major findings of the Science Council survey which have relevance to the current study are incorporated into the discussion of the data in Chapter 4.

The summary of the data collected by the Science Council survey provide the most comprehensive picture of science education in Canada available to date. Unfortunately, the data analysis is limited to comparisons between male and female teachers and among elementary, middle, and senior year teachers. The relationships among teachers' opinions and demographic variables such as training and teaching experience were not undertaken.

Of the eight case studies conducted in the Science Council study, four were set in senior high schools (Olson & Russell, 1984). Although the science departments studied were widely separated geographically, many common themes were found among teachers' views of science and science teaching. Five of the major themes follow:

1. Teachers feel a tension between covering the required and considerable subject matter in order to lay the foundation for future work, and promoting student interest in that work.
2. Teachers view science as a method of precision characterized by exact numbers and highly organized bodies of information with specialized terminology.
3. Alternative teaching approaches, such as stressing inquiry processes, relating science to social issues, or relating science to technology are not seen as central activities for the science classroom but as a means of encouraging student interest.
4. Student laboratory work is viewed as illustrating and confirming theories presented in the classroom.
5. Mathematical problem solving is stressed in physics and chemistry, and students spend considerable time working out problems in order to apply principles and get correct answers.

Olson and Russell also found that the case studies revealed, "a complex web of interacting factors", which influenced teachers' decision-making. In particular they found the following matters to be major concerns of teachers: maintaining their credibility, exerting their influence, gaining access to scarce resources, and coping with conflicts between outside expectations and the realities of the classroom. The case studies seem to indicate the use of science content to socialize students and protect the teacher's social position in the school as noted by Stake and Easley (1978) and Aikenhead (1983). The major themes of the Science Council case studies will be compared to the themes gleaned from the observation and interview data in the current study.

One of the major conclusion of the Science Council study is that there is a, "serious gap between what science education is supposed to achieve and what it actually achieves" (Science Council of Canada, 1984, p. 10; emphasis in the original). In other words, the Science Council study illustrates again the difficulty of translating the intentions of curriculum developers and school authorities into classroom practice. If the various recommendations of the Science Council report are to have any real impact on what goes on in the classroom, the process of translating the intended curriculum into classroom practice will need to be understood and heeded. The current study is an attempt to contribute to this understanding.

Second International Science Study

Canada is a participant in the Second International Science Study (SISS), which was initiated and coordinated by the International Association for the Evaluation of Educational Achievement (IEA). In broad terms the SISS is aimed at gathering information about what the IEA refers to as the *intended*, the *translated*, and the *achieved* science curricula in each of the participating countries. A major outcome of the Canadian component of the SISS was the preparation of a national case study which describes the processes by which science curricula are developed, implemented, and supervised in Canada (Connelly, Crocker, & Kass, 1984). The SISS national case study compliments the data collected by the Science Council study, providing a comprehensive picture of science education in Canada.

As a major part of the Canadian component of the SISS, a teacher perception study was undertaken, to gather information about teacher thinking as it relates to the nature of curriculum and curriculum change. In particular, the teacher perception study was aimed at gathering information about the factors which influence the process of curriculum translation. The sample for the teacher perception survey was drawn by selecting a separate sample from the population of grades 5, 9, and 12, in each of the provinces and territories in Canada. The total sample included 799 grade 5 teachers, 711 grade 9 teachers, and 1447 grade 12 teachers.

The teacher perception study used a policy-capturing technique (Shavelson & Stern, 1981) in which teachers were presented with scenarios centering around a hypothetical move of a teacher to a new school. The scenarios consisted of three scenes, and each scene consisted of a set of vignettes describing conditions and events at successive stages of the move. The description of each vignette contained one level of each of several factors related to features of the new school and a proposed curriculum pilot. The factors were systematically varied to yield all possible combinations of the levels of each factor in the design (32 in all). The effects of the factors and their interactions were examined by means of an analysis of variance.

Responses to the first scene, describing an initial visit to the school, indicate that the characteristics of the students in the new school are the most important factor influencing teachers' perception. Teachers were more positive toward schools which were well equipped, had a high level of community support, and where the emphasis was on learning how to learn than toward schools where this was not the case.

The second scene described the situation during the first few days at the new school. Not surprisingly, analysis of the teacher responses indicated that schools which were well equipped, had a strong school spirit, and a policy of student self-discipline were viewed more positively than their opposites. An interaction between school spirit and facilities indicated that if school spirit was poor, facilities didn't matter. The responses also indicated that staff relationships were not an important factor in teacher perceptions.

The third scene described a situation, occurring after several months in the new school, in which the teacher was asked to pilot some new curriculum materials. The data analysis indicated that small group work was strongly favored over whole group instruction, and that teachers have a slight preference for curriclum materials which include a student text over materials that do not have a text. An interaction between methods and student ability indicated that teacher preferred small group methods with low ability students.

The teacher perception study also gathered general information about the teachers in the sample, their teaching assignments, instructional practices, and decision-making.

Some of the findings of the policy-capturing instrument are not consistent with what teachers indicated was the practice in their classrooms. In particular, teacher preference for small group work is not consistent with the prevailing practice of teacher presentation. The discrepancy here is likely due to a difference in meaning between the hypothetical situations described in the scenarios and the reality of the teachers' own classroom (Deutscher, 1966). Even though teachers are likely responding ideally to the hypothetical situations described in the scenarios, the SISS teacher perception study has identified some of the factors from the teaching situation which likely influence teacher decision-making. A continued study of teacher perceptions has been proposed for Phase II of the SISS. The proposed study would make use of intensive research methods, such as a Q-sort in conjunction with a structured interview, to probe the reasons why teachers make particular types of decisions. The proposed study seems to be a promising means of revealing how the functional paradigms of teachers guide their decision-making, and may also identify some of the influences which shape the functional paradigms of teachers.

E. Chapter Summary

The discrepancy between curriculum policy and practice is rooted in the distinction that Western philosophy makes between theoretical and practical knowledge. Most of the attempts to reconcile curriculum policy and practice ignore or denigrate the practical knowledge of the classroom teacher. The current study uses the symbolic interactionist theory of personal meaning to investigate the translation of the stated curriculum into classroom practice, by examining teachers' interpretation of curriculum materials.

By combining qualitative methods (e.g., classroom observations and focused interviews) with quantitative research methods (e.g., survey questionnaires), a more adequate picture of the translation process can be obtained than from using either one alone. With both qualitative and quantitative research, assessments of validity and reliablity ultimately rest on subjective judgement. While validity is indicated by agreement among independent methods of assessment, reliability is indicated by agreement among similar methods of assessment separated by time and location. While professional judgement can be used to assess the face and content validity of survey instruments, the most direct method of assessing the validity of qualitative data is to ask participants to confirm or disconfirm the descriptions and interpretations. The best assurance of validity in qualitative research seems to be good researcher-participant relations.

Studies of science curricula in practice consistently indicate a wide gap between the intentions of curriculum developers and school authoritities, on one hand, and classroom practice on the other. Research indicates that factors emanating from the classroom have the strongest influence on teachers' curricular decisions. Studies of curriculum decision-making indicate that teachers' beliefs and values play a central role in determining how curriculum materials are used in the classroom.

III. DESIGN OF THE STUDY

In this chapter the development of the instruments and procedures for conducting the observations, interviews, and surveys are outlined. In addition, the methods used to select the survey sample and to analyze the qualitative and quantitative data are described.

A. Survey Instruments

In this section the development of the classroom observation sheets, the interview questions, the Student Opinion Survey (SOS), and the Chemistry Classroom Practice Survey (CCPS) is described.

Classroom Observation Sheets

Two observation sheets were prepared in advance of the school visits, in order to provide a focus for the classroom observations and to facilitate note taking and later analysis (Hartmann, 1982). One of the observation sheets relates to the structure and organization of the classroom / lab and the other relates to the teaching strategies used during the lessons. Copies of the observation sheets are contained in Appendix C, and the outline of the observation sheets is used to organize the field notes contained in Appendices G, H, and I.

The "classroom / lab" observation sheet focused on the physical features and organization of the room where the observed classes were taught. The first point on the sheet called for a description of the main features of the room, followed by points regarding windows, blackboards, tackboards, shelves and cupboards, audiovisual and other special equipment. Ample room was left to describe and comment on wall charts, posters, newspaper clippings, and other teaching aids. The ideas for points to include on the observation sheets were based on my experience in visiting numerous chemistry classrooms as a faculty consultant for student teachers.

The "teaching strategies" observation sheet focused on the actions of the teachers and students, and the use of curriculum materials during the chemistry lesson observed. Space was left for noting teacher comments which reflected something of their perceptions in the following areas; science, students, teaching, and society. Another function of the second observation sheet was to note points about the teacher's use of the ALCHEM materials which could be discussed with him during the subsequent interviews.

Interview Questions

In order to provide a common reference point for the teacher interviews, a set of guiding questions focusing on teacher use of the ALCHEM materials were developed. The guiding questions were framed so that information on particular aspects of ALCHEM would be obtained while allowing the teacher to stress the areas of his classroom practice which he felt were most important. The questions were designed so that classroom observations could be incorporated into the discussions to provide a triangulation type of validity check (Denzin, 1970). The intention was to preserve a sense of collegiality and trust in the interviews, in order to establish research conditions which are favorable for validity (Shatzman & Strauss, 1973). An attempt was made to frame the questions so that they did not suggest an evaluative judgement on the teachers' classroom practice, but rather communicated the message that their opinions were respected and their practice was worthy (Dean & Whyte, 1969). The following outline was used to introduce and guide the initial interview:

> My study has to do with teacher use of the ALCHEM materials, that is, how teachers use ALCHEM and what their reasons are for using it the way they do. Basically, what I want to find out is how teachers use their own common sense to modify and adapt the ALCHEM materials to make them work in their classroom.

1. In general what do you think of the ALCHEM materials?
2. Are their any parts of ALCHEM that you omit? (e.g., labs, demos, exercises)
3. Are their any parts of ALCHEM that you supplement? (e.g., films, additional notes, labs, demos)
4. Are their any parts of ALCHEM that you adapt or modify?
5. Which elective units do you use?

A pilot study with Mr. Brown, a chemistry teacher in an urban high school, indicated that the guiding questions were a nonthreatening stimulus for teachers' reflection on their classroom practice. The general sense of the interviews was that of two chemistry teachers "talking shop". The transcripts of the interviews provided a data base from which teacher interpretation of curriculum material could be gleaned.

The guiding questions were printed on a sheet with ample space allowed for the interviewer to take notes during the interview. Numerous researchers (Crocker, 1979; Roth & Werner, 1981) have recommended note-taking during interviews as a valuable practice because it aids later analysis of the transcripts, allows noting details of the situation which might be forgotten later, and it indicates to the interviewee that the researcher is interested in what he is saying. With each teacher, notes and transcripts of the first interview were studied to formulate additional questions which were discussed in subsequent interviews. The follow-up questions were aimed at clarifying the intitial comments, checking interpretations of the teacher's statements, and probing ideas that seemed particularly interesting. These verifications of the researcher's interpretation provided an ongoing validity check (McDonald & Walker, 1974).

Student Opinion Survey (SOS)

The Student Opinion Survey (SOS) was designed to obtain students' opinions of the ALCHEM materials. A summary of student responses to the SOS was discussed with the respective teachers. The intention of the SOS was to provide an additional stimulus for teacher reflection on the ALCHEM materials and his day-to-day use of them, therby revealing more information about the interpretive process used in translating the intended curriculum into classroom practice.

In the SOS, fourteen different aspects of the ALCHEM materials are identified, e.g., "the objectives listed at the beginning of each unit", "the explanations of chemical concepts and principles", and "the lab work". To help clarify the description, each aspect was illustrated with an appropriate example from the materials. A draft version of the SOS was given to each of six ALCHEM authors to get their assessment of its content validity (Cronbach & Meehl, 1967). The authors were unanimous in their opinion that the SOS was an adequate description of the ALCHEM materials and that it would provide valid information on student opinions of the material. Students were asked to respond to each aspect from the following three points of view:

1. usefulness in helping them gain an understanding of chemistry
2. usefulness in helping them prepare for exams
3. whether or not they found the information or exercise interesting

The ratings were done on a five-point Likert scale where "1" was the low end of the scale ("useless" or "boring") and "5" was the high end of the scale ("very useful" or "very interesting"). The students were asked to rate the materials from these points of view because its was felt that they represent three major concerns about curriculum materials which are shared by students and teachers alike. That is, do the curriculum materials help students understand the course content, do they help students prepare for exams, and do students find them interesting? By asking students to rate the materials from the point of view of exam preparation, the intention was to provide teachers with feedback on what students considered important for passing their teacher's exams.

A preliminary draft of the SOS, based on the ALCHEM 20 materials, was prepared and piloted in January, 1982. The draft version of the SOS was administered to all the students in attendance in a large academically oriented urban high school. The administration took place over a two-day period during the last week of the semester. The students took between 20 and 30 minutes to complete the SOS. A total sample of 100 students responded to the questionnaire (46 boys and 54 girls), representing approximately 50% of the students who were enrolled in Chemistry 20 during the first semester. Classes of three different teachers were included in the sample. The SOS was revised on the basis of the student responses and the comments of the teachers whose classes were involved. For example, an item on the ALCHEM wall charts was deleted since they are not part of the textbook, and the item on "cartoons" was changed to "illustrations". A section of the SOS which asked students to identify aspects of the ALCHEM 20 text which were, "not really part of the Chemistry 20 course", was dropped because it did not capture any additional information and added to the length of the questionnaire.

A different form of the SOS was prepared for each of ALCHEM 10, 20, and 30, with the illustrations for each form taken from the corresponding materials. Twelve of the aspects of ALCHEM which are identified in the SOS are common to all three forms, while two questions on each form refer to aspects which are unique to the respective

ALCHEM text, e.g., an item about the ALCHEM data sheet appears only in the ALCHEM 30 form of the SOS. It should be noted that students were asked their opinion of the format of the materials and the manner of presenting the chemistry content, but *not* about the content iteself. Copies of the SOS are contained in Appendix D.

The ALCHEM 10, 20, and 30 versions of the SOS were piloted in November, 1982, with the students of Mr. Brown, the same chemistry teacher with whom the interview questions were piloted. The ALCHEM 10, 20, and 30 versions of the SOS were completed, respectively, by 29, 55, and 52 students. Mr. Brown indicated that the summary of student responses was generally consistent with his use of the materials in class. He seemed very interested in the students' ratings of the materials, and they seemed to be an effective way of stimulating reflection on his use of the ALCHEM materials in his classroom. Thus the pilot study indicated that the SOS was a valuable instrument, both as an additional source of information about classroom use of ALCHEM and as a stimulus for reflection and discussion with the classroom teacher.

Chemistry Classroom Practice Survey (CCPS)

The Chemistry Classroom Practice Survey (CCPS) was developed to gather additional information about teacher interpretation of curriculum materials from a larger sample of teachers than could be observed and interviewed in person (Fullan & Pomfret, 1977). The CCPS was designed to obtain information which paralleled that obtained from the classroom observations and teacher interviews.

Development of the CCPS began early in January 1983. Many of the ideas for the general sections of the questionnaire as well as for specific items were drawn from the classroom observation and teacher interviews done during the first and second stages of the study. In particular, the sections on factors considered in selecting and adapting curriculum materials, on teaching strategies, and on teacher use of the ALCHEM materials were designed to parallel the teacher observations and interviews. Additional ideas for items were gleaned from questionnaires used in other science education studies (Hobbs & Erickson, 1980; Brauer, 1981; Orpwood & Alam, 1984). All potential items were categorized into the five topical areas: background information on the teacher, the school, and the community; objectives of the Alberta high school chemistry program; factors considered in selecting and adapting curriculum materials; teaching strategies; and information on teachers' use of the ALCHEM materials. Within each topical group the items were arranged in a sequence which would appear logical to the prospective respondent. A first draft of the questionnaire was prepared and piloted with five chemistry teachers in a large urban high school. In addition to responding to each of the items in the CCPS, the pilot teachers were asked to note how long it took them to complete the questionnaire and to comment on any items they felt were ambiguous or unclear. In addition, the CCPS was scrutinized by three university researchers who are experienced in survey research (Cronbach & Meehl, 1967; Ebel, 1972; Kerlinger, 1973). The responses and comments of the pilot teachers and university researchers were used to guide revision of the instructions and the items.

A principal concern in preparing and revising the questionnaire was to word the instructions so that the intent was clear to the respondents (Fiske, 1981). One area that needed revision was the section on frequency of use of particular teaching strategies. It became apparent that words such as "rarely", "occasionally", and "frequently" were too vague to provide reliable information. Most of the teachers who completed the draft version of the CCPS checked "occasionally" for most items. These items were revised by replacing the original descriptors with frequency estimates, such as, "about once or twice a month", and "almost every class period".

A copy of the CCPS is included in Appendix E. The questionnaire is divided into six sections. Section 1 (Background Information) was designed to capture basic demographic information about Alberta chemistry teachers and the schools in which they teach. In Section 2 (Objectives of the Alberta Chemistry Program) teachers were asked to rate each of the 17 objectives listed in the Alberta Education document, *Curriculum guide for senior high school chemistry (1977)*, according to how much emphasis they placed on that particular objective in their chemistry teaching. The ratings were done on a five-point Likert scale where "1" represented "no emphasis", and "5" represented "heavy emphasis". In Section 3 (Selecting and Adapting Curriculum Materials) teachers were asked to indicate, on a five-point Likert scale, how important they considered each of 14 different factors in determining how they use curriculum materials in their chemistry classrooms.

Section 4 (Teaching Strategies) was designed to gather information on how frequently teachers use each of 15 different teaching methods in their chemistry classes. The items in Section 4 use multiple choice format with the following choices:

A. Never or rarely
B. About once or twice a semester
C. About once or twice a month
D. About once or twice a week
E. Almost every class period

At the end of Section 4 teachers were asked to indicate whether they had ever used any of the ALCHEM materials for teaching high school chemistry. Those who had used ALCHEM were asked to complete Sections 5 and 6, while those who had not used ALCHEM were instructed to leave these two sections blank. In Section 5 (Rating the ALCHEM materials) teachers were asked to indicate the nature and extent of their use of ALCHEM, and then to rate 12 different aspects of the materials from the point of view of usefulness to them in teaching high school chemistry. The 12 aspects of ALCHEM listed in this section of the CCPS are those which are common to all three forms of the SOS. The intention here was to gain some information which would allow comparisons of teacher and student opinions on ALCHEM. As with the SOS, the CCPS ratings were done on a five-point Likert scale were "1" corresponded to "useless" and "5" corresponded to "very useful".

Section 6 (Comments on ALCHEM) consisted of seven open ended questions regarding teacher use and opinions of the ALCHEM materials. The first five questions in Section 6 were the same as the guiding questions used in the initial interviews with three selected chemistry teachers. The intention here was to gather data from the larger sample which was parallel to that gained from the three teachers who were interviewed. The final two questions in the CCPS asked teachers to indicate what they would add to, or remove from, a revision of the ALCHEM materials. The intention of these two questions was to gather information on what teachers regard as the most important function of curriculum materials.

In the instructions for the CCPS, the chemistry teachers were asked to write all their responses in the questionnaire booklet. They were instructed to circle the letter of the appropriate response for the multiple choice items, the appropriate number for the

Likert scale items, and to write their comments on the open-ended items in the space provided. A separate answer sheet was not used because it was felt that the task of recording the responses on a separate sheet of paper could introduce errors as well as reduce the response rate.

B. Data Collection

In this section the procedure for conducting the teacher observations and interviews is described, and the method of administering the Chemistry Classroom Practice Survey (CCPS) questionnaire is outlined.

Teacher Observations and Interviews

In selecting teachers for observation and interview, an attempt was made to find teachers with a variety of training and experience, working in a variety of situations (Stake & Easley, 1978, Olson & Russell, 1984). The three teachers selected were chosen from the population of Alberta chemistry teachers who were using the ALCHEM program. Chemistry teachers who had worked on writing ALCHEM materials were excluded from the sample because it was felt that their background knowledge of the intentions of the program would not be typical of most classroom teachers. The willingness of the classroom teacher to be observed and interviewed was an essential consideration, as was the proximity of the school. One of the teachers selected works in a high school which serves a small town and a large rural area in Alberta, while the other two teach in large urban high schools which differ from each other somewhat in terms of student population and academic program. All three teachers are male. Two are in their early forties and one in his mid-twenties. More detailed descriptions of the training, experience, and teaching situations of the three teachers are given in Chapter 4. After the informal consent of the teachers had been obtained, an application was submitted to the relevant school jurisdictions for official permission. In the official application the research project was described as follows:

> The research project is an investigation of the role of teachers' personal practical knowledge in the interface between the intended high school chemistry curriculum and classroom practice . The intended chemistry curriculum is taken to be the program outlined in the document *Chemistry 10 20 30 curriculum guide* (Alberta Education, 1977) and operationalized by the

> ALCHEM 10, 20, and 30 materials (Jenkins et al, 1976). Classroom practice refers to all of the learning activities planned and carried out by the teacher, including selecting and using curriculum materials (e.g. notes and activities), presenting course content, and evaluating student achievement. I wish to examine how the teacher translates the mandated chemistry curriculum into classroom experiences for students and to identify the factors which the teachers must consider in making this translation.
>
> The study will involve visiting one teacher four or five times over a period of ten weeks. The central aspect of each visit will be a teacher interview focusing on how and why the teacher modifies and adopts the ALCHEM materials for use in his classroom. In addition, each visit will include observation of classroom and lab activities, focusing on actual use of the ALCHEM materials. During the course of the visit the researcher will ask to examine materials developed by the teacher which pertain to teaching chemistry.
>
> The only instructional time that would be lost is approximately thirty minutes for having students complete a questionnaire that asks their opinion of the ALCHEM materials. The questionnaire responses will be compiled by the researcher and returned and discussed with the teacher.

The purpose of the observations and interviews were disclosed to the three teachers when the request was made for their participation in the study. No attempt was made to mask the purpose of the research. Table 2 gives the schedule of the observations and interviews which were done over a four-month period from the beginning of February to the end of May, 1983. The observations and interviews with each teacher were spread out over the four months to increase the range of topics being taught and to allow time for studying notes and transcripts. Each school site was visited five times and in each school the administrator who had responsibility for the science program was interviewed to gain background information about the school's programs and the nature of the community. In particular, the interviews with the school administrators focused on the course offerings and enrollments in the science program. In the two schools that had designated science department heads, the school's science program was discussed with them as well.

The Student Opinion Survey (SOS), described earlier in this chapter, was administered to all the chemisty students of the three teachers. The SOS was given during a regular class period at a time convenient to the teacher, and typically took fifteen to twenty minutes to complete. Only the ALCHEM 10 and ALCHEM 30 forms of the survey were used, since none of the three teachers were teaching Chemistry 20 during the semester that the research was conducted. The number of classes and students involved

Table 2
Schedule of Observations and Interviews

February 9	-visited Parkland High in afternoon (3.0 h). -observed Allan's Chem 10 class on atomic structure. -first interview with Allan in his office.
February 16	-visited Parkland High in morning (3.5 h). -observed Allan's Chem 30 class on hydrocarbon nomenclature. -interviewed Assistant Principal in conference room. -second interview with Allan in his office.
February 21	-visited Glenview High in morning (3.5 h). -observed two of Kurelek's Chem 10 classes on atomic structure. -interviewed Assistant Principal in timetable room. -first interview with Kurelek in his classroom.
February 22	-visited Rutherford High in morning (3.0 h). -observed Jensen's Chem 10 class on review of bonding and nomenclature, and his Chem 30 class on heats of reaction. -first interview with Jensen in staff room.
March 23	-visited Parkland High in morning (3.0 h). -observed Allan's Chem 30 class on remedial work. -third interview with Allan in his office.
April 6	-visited Glenview High in morning (3.0 h). -observed Kurelek's Chem 10 class on chemical bonding. -second interview with Kurelek in science workroom. -interviewed science department head in science workroom.
April 13	-visited Rutherford High in morning (3.0 h). -observed Jensen's Chem 30 class on electrochemistry. -second interview with Jensen in the science workroom.
April 14	-visited Parkland High in morning and afternoon (4.0 h). -observed Allan's class on heat stoichiometry. -administered SOS to Allan' Chem 10 class (24 students) and Chem 30 class (29 students). -fourth interview with Allan in his office.
April 21	-visited Parkland High in afternoon (2.0 h). -fifth interview with Allan in his office. -discussed SOS summary with Chem 10 class.
May 5	-visited Rutherford High in morning and afternoon. -observed Jensen's Chem 30 class on pH calculations. -administered SOS to Jensen's two Chem 10 classes (42 students) and two Chem 30 classes (36 students).
May 11	-visited Rutherford High in morning (2.0 h). -third interview with Jensen in staff room. -interviewed science department head in his classroom.
May 19	-visited Glenview High in morning (3.0 h). -observed Kurelek's class in laboratory (molar masses). -administered SOS to Kurelek's two Chem 10 classes (56 students).
May 24	-visited Glenview High in afternoon (1.0 h). -third interview with Kurelek in his classroom.

for each teacher is given in Table 2. Student responses on the SOS were tabulated, and mean ratings and standard deviations were calculated for each item. The survey results were summarized and discussed with the teacher concerned during the final interview.

In all cases I was received cordially and accepted as a fellow chemistry teacher who was gathering some data on ALCHEM. Although the focus of my research was explained in general terms during the first interview and reiterated with each visit, the teachers seemed to have some difficulty understanding my interest in their personal interpretation of the chemistry curriculum and their reasons for using curriculum materials as they did. They seemed more comfortable with the idea that I was evaluating the ALCHEM materials with the view of making suggestions for future revisions. It became apparent that the most effective line of investigation would be to focus the interviews on a discussion of the teachers' modifications of ALCHEM and their ideas for improvements in the materials. From these discussions I would be able to infer what the teachers' interpretations of the materials were and thereby gain some insight into the nature of their functional paradigms.

Although all the teachers had agreed to be interviewed and all seemed comfortable with the interview process, it was not always easy to find time for the interviews. Although each visit was arranged in advance and the teachers were always reminded by telephone the night before, in some cases it was apparent when I arrived in the classroom, that the teacher had forgotten about our arrangements. In two cases interviews had to be cancelled because the teachers had other commitments. The general impression was that the teachers were preoccupied with their teaching and other responsibilities in the school, and had more on their mind than my research project. Once into the interview, however, the teachers seemed quite at ease and spoke freely about the joys and frustrations of teaching high school chemistry, about teaching strategies developed and modified over years of experience, and about their reasons for using curriculum materials the way they did.

When I sat in on classes, the teachers generally introduced me as, "Mr. Lantz from the University", and told the classes that I was doing some research on the ALCHEM texts that they were using. During the teacher's presentation I sat at the back of the room taking notes. When students were given class time to work on assignments, I moved around the room talking to students and providing individual assistance when it was requested.

Chemistry Classroom Practice Survey

The sample for the teacher survey was obtained by randomly selecting one-fifth of the 242 high schools in Alberta which offer a complete Chemistry 10, 20, and 30 program. The sample was drawn in conjunction with the Alberta chemistry sample for the Teacher Perception Survey of the Second International Science Study (SISS) which was being carried out at the same time (Connelly, Crocker, & Kass, 1984). The SISS sample was drawn from a list of Alberta high schools, listed by jurisdiction. A set of 80 random numbers, ranging from 1 to 250, was computer generated and the schools corresponding to these positions on the list were selected to be part of the IEA chemistry sample. To avoid overlapping with the SISS chemistry sample, the sample for the current study was drawn by selecting schools in the list which appeared immediately after those in the IEA sample, omitting every fourth school obtained in this way. A sample of 50 schools from 32 different jurisdictions was drawn by this method.

For administrative purposes Alberta Education divides the Province of Alberta into nine geographical zones. For each zone Table 3 indicates the number of schools where Chemistry 30 is taught, the number of schools drawn for the study sample, the number of schools responding, and the percent response rate. The distribution of teachers in the sample by size of community and school is given in Table 12 in Chapter 4. The data in Table 3 show that the all nine zones are represented in the sample drawn for the chemistry classroom practice survey, indicating that the sample includes schools from all parts of the Province.

A letter was written to the Superintendents of each of the 32 jurisdictions, outlining the purpose of the study and requesting permission to contact the principals of the sample schools with regard to the CCPS. The second page of the letter included a form on which the superintendent was requested to check "yes" or "no", to sign, and to return promptly. The letters were mailed during the first week of May, 1983. A sample of the letter to the Superintendents in included in Appendix F. As permission forms were returned, packages of the CCPS were mailed to the principals of the respective schools.

Table 3

Distribution of CCPS Sample Schools

Zone Number	Number of High Schools	Number of Schools Selected	Number of Schools Responding	Percent Return Rate
1	24	5	2	40.0
2	45	4	4	100.0
3	36	12	11	91.7
4	35	7	3	42.9
5	28	5	4	80.0
6	32	7	3	42.9
7	12	3	3	100.0
8	12	3	3	100.0
9	18	4	3	75.0
Total	242	50	37	74.0

The covering letter to the principal requested his cooperation in distributing the CCPS to the chemistry teachers in his school and in ensuring that the completed questionnaires were returned by the end of May, 1983. A sample of the letter to the principals is contained in Appendix F. Since the total number of chemistry teachers in each school was not known, the numbers were estimated by doubling the number of Chemistry 30 teachers in the school (information which was available from Alberta Education).

Two weeks after the superintendents' letters were mailed, affirmative replies had been received from 22 jurisdictions. The remaining 10 jurisdictions were telephoned and inquiries made about the research request. Since no refusals were encountered, packages of questionnaires were mailed to the remaining schools in the sample. By the first week in June completed questionnaires had been returned from 30 of the sample schools. At this time the twenty remaining schools were phoned and the principal or one of the school's chemistry teachers was queried about completing and returning the CCPS. In most cases assurance was given that the questionnaires had been mailed or were being worked on and would be mailed as soon as possible. Only in one case was there an indication that the questionnaire would not be returned. In this case the teacher, from a small rural school, responded to the query about completing and returning his copy of the CCPS with the comment:

> I teach all the chemistry and all the biology in the school. I spend all my time preparing and when it comes to filling out forms I usually don't have time.

This individual was likely speaking for many other teachers in similar situations. As a consequence, teachers in small schools who teach a large number of different science courses without assistance from laboratory aides, may be under-represented in the returned questionnaires.

As the data in Table 3 indicate, the school response rate varies from 42.9% to 100.0% among the nine zones of the province, averaging 74.0% overall. The response rate is 67.5% for zones 1 to 6 which are comprised predominantly of rural schools, and 90.0% for zones 7 to 9 which are entirely comprised of urban schools. These data support the suggestion made earlier that rural schools may be somewhat under-represented by the returned CCPS questionnaires. A total of 69 teachers responded to the CCPS for a teacher response rate of 61%. The teacher response rate was calculated by multiplying the average response rate *within* corresponding schools (approximately 83% as estimated from CCPS data) by the overall school response rate (74%). These response rates are very similar to those in the Science Council Study (Orpwood & Alam, 1984) where the response rates were 72% for schools and 61% for teachers.

C. Data Analysis

Analysis of the verbal data collected in the current study was expedited by use of the University of Alberta Amdahl 5860 mainframe computer, which uses the Michigan Terminal System (MTS) as an operating system. Extensive use was also made of the Amdahl computer in analyzing numerical data collected by the various instruments used in the study.

Qualitative Data

Notes made during the classroom observations were used to describe the classroom setting and teaching strategies. Points noted during the classroom observations were also incorporated into the subsequent interviews, to aid interpretation of both the interviews and the observations. Questions about the observations helped to stimulate teacher reflection on their classroom practice, and comments made in the interviews helped to interpret the observations.

The interviews were tape recorded and a professional stenographer was employed to type verbatim transcripts of the interview tapes into a computer file. The stenographer was instructed to insert a string of question marks wherever she could not decipher the tape. By listening to the relevant sections on the tape I was able to decipher all the passages marked in this way. These passages were infrequent, and usually involved the use of technical words specific to chemistry, or situations in which the background noise obscured the conversation. Having the transcripts on a computer file facilitated making corrections to them. The stenographic transcripts were found to be accurate renderings of the tapes, often revealing more about the speech patterns and thought processes of the teacher and researcher than either of them cared to know. All the hesitations of speech and slang expressions were left in the transcripts, but many of the run-on sentences were broken down to shorter sentences to make it easier for readers to follow the thread of the interviews. Transcripts of the interviews with the three teachers are contained in Appendices G, H, and I.

The interview transcripts were combed to find recurring themes (Rist, 1982). To help find themes, teachers comments were categorized under the following four *curriculum commonplaces* (Schwab, 1971): chemistry, teaching, students, and school setting. Themes were then sought within each category. Since the interview transcripts were were on a computer file, it was possible to use the scan function in the MTS file editor to search each transcript for certain key words. When a key word was found, the line containing it was automatically printed out along with the line number, so that the context in which the word was used could be examined. Some of the key words searched for were: *time*, *lab*, *chemistry*, *student*, and *teach*.

After the transcripts were analyzed, a summary was written of the main themes that emerged with each of the teachers. These summaries indentified elements in the practical knowledge of the teachers which influenced the manner in which they translated curriculum materials into practice in their classrooms. Each summary, along with the relevant transcripts and a description of the school and classroom setting, were given to the respective teachers for their reaction (Dawson, 1979). The following instructions were given in the covering letter to the teachers:

> Enclosed is the portion of my thesis which is based on the observations I made in your chemistry classes, and on my interviews with you. The typed transcripts of the interviews are enclosed as well. As you will notice, the names of people have been changed to maintain confidentiality.
>
> Basically, my thesis is an investigation of how chemistry teachers interpret curriculum materials for use in their classes. I would like you to read over what I have written about my observations in your classes and my interviews with you. Please comment on the following points (feel free to write directly on the pages):
> 1. The accuracy of the background information on the community, the school, yourself, and your classes.
> 2. The validity of my statements about how you interpret curriculum materials in your classes.
> 3. Any information which you feel would violate the confidentiality of our discussions.
>
> When you have had a chance to read these materials, I would like to discuss them with you.

All of the teachers seemed very interested in what I had written about them. Each teacher picked up some typing errors in the interview transcripts and a few minor factual errors in the descriptions of the school and classroom, but they did not find any information that they thought would violate the confidentiality of the study. The two experienced teachers commented that it was interesting to get another teacher's perception of what they were doing in their classroom, and the beginning teacher said that my description was, "right on". All three teachers indicated that my statements about how they interpreted curriculum materials were valid.

The responses to the open-ended questions in Section 6 of the CCPS were analyzed by collating the teachers' written responses under the same four headings used with the interview transcripts, i.e., chemistry, teaching, students, and school setting. Tallies were made of the number of people giving similar responses and themes were sought within each of the categories.

Quantitative Data

On the Student Opinion Survey (SOS), students indicated their ratings of the ALCHEM materials on an optically scored answer sheet. The Sentry 7008 Program: GPSCOR was used to collate the data directly from the SOS answer sheets and to store it in a computer file. The QUESEVAL program was used to tabulate student responses on each item and to compute the mean and standard deviation of the ratings on each item.

On the Chemistry Classroom Practice Survey (CCPS), teachers wrote all their responses directly in the CCPS questionnaire. Numerical data from Sections 1 to 5 were entered directly from the questionnaires into a computer file. Frequency tabulations and crosstabulations were done on these data using standard programs from the Statistical Package for the Social Sciences (SPSS) library (Nie et al, 1975).

Sampling Error

Much of the data obtained from the CCPS questionnaire is presented either as proportions of teachers, expressed as a percent, in various categories, or as mean ratings on a five-point Likert scale. Standard sampling errors were calculated for alpha = .05, for proportions of 50%, 25%, and 10%. The sampling errors were calculated using the following formula (Ferguson, 1976):

$$\text{sampling error} = \pm 100\sqrt{(pq)/N}$$

where, N is the sample size

p is the proportion

q is (1-p)

In the calculations, N was taken to be 65, since that was the smallest number of respondents to any item on the CCPS. The calculations revealed that if 50% of the respondents to a particular item on the CCPS select a certain category, the 95% confidence interval for that proportion is 37.8% — 62.2%. For a proportion of 25% the 95% confidence interval is 14.5 — 35.5, and for a proportion of 10% it is 2.7 — 17.3. Ferguson states the formula used here for calculating the standard error of a proportion should not be used for extreme values of p and q. He suggests that the formula is only valid in cases where Np or Nq, whichever is smaller, is equal to or greater than 5. Using this guideline where the number of respondents is 65 would mean that the formula should not be used when the proportion is greater than 92% or less than 8%.

For the data presented in the form of means and standard deviations the standard error is estimated by the following relationship (Ferguson, 1976):

$$\text{sampling error} = \pm S/\sqrt{N}$$

where, S is the standard deviation for the data at hand

N is the sample size

With a sample size of 65 and a standard deviation of 1.00 the standard error is estimated to be 0.12. In general, the probability is 95% that means will be within the range of ±0.24 about the sample means. There will be slight variations depending on the actual number of responses and the standard deviation on individual items.

The sampling error was computed as though the teachers had been selected randomly, rather than the schools. This condition will lead to calculated values which are slightly smaller than the true values. The computations were also done on the basis of single independent proportions. In most of the items on the CCPS, however, teachers were selecting one out of five categories, so that the proportions for these categories were not independent. This condition will give calculated values which are somewhat larger than the true values. Since these two conditions tend to cancel each other, the calculated values are likely quite close to the actual values (Walker & Lev, 1953).

The calculations outlined above indicate a fairly wide confidence interval due to the relatively small sample size. Although the data from the CCPS will be adequate to give a general picture of the population of Alberta chemistry teachers, the test is not powerful enough to pick up small differences between groups of teachers.

Discriminant Analysis

Discriminant analysis (Kerlinger, 1973; Nie et al, 1975; Hunka & Maguire, 1982) was carried out on some of the data from the CCPS in an attempt to identify some demographic variables which might be associated with differing perceptions of teachers. A brief account of discriminant analysis follows.

Discriminant analysis is designed to distinguish statistically between two or more groups of cases using a collection of discriminating variables. The selected variables measure characteristics on which the groups are expected to differ. The mathematical objective of discriminant analysis is to weight and linearly combine the discriminating variables in a manner that makes the groups as statistically distinct as possible. The object is to be able to "discriminate" between the groups in the sense of being able to tell them apart. The discriminant function is is expressed mathematically as follows:

$$Di = di_1Z_1 + di_2Z_2 + \ldots + dipZp$$

where, Di is the score on the discriminant function, i.

$di_1, di_2, \ldots dip$, are the weighting coefficients

$Z_1, Z_2, \ldots Zp$, are the standardized values of the discriminating variables

The weighting coefficients serve to identify the variables which contribute most to differences along a particular dimension, and the sign indicates whether the variable is making a positive or negative contribution.

Often there are more variables than necessary to achieve satisfactory discrimination. In this case a stepwise procedure is used to select the best combination of variables. The stepwise procedure begins by selecting the single best discriminating variable on the basis of a user determined criterion. A second discriminating variable is selected as the variable best able to improve the discriminating criterion in combination with the first. Subsequent variables are also selected according to their ability to contribute to further discrimination. At each step, variables already selected may be removed if they are found to reduce discrimination when combined with more recently selected variables. The procedure continues until all the variable able to contribute to further discrimination have been selected.

At the end of the stepwise discriminant analysis procedure, certain statistics are generated which indicate the relative ability of the function to separate the groups. One such statistic is the chi-square which can be used as a test of significance. Another useful indicator is the canonical correlation coefficient, a measure of association between a single discriminant function and the group variable, which indicates the function's ability to discriminate between groups. The square of the correlation coefficient represents the proportion of variance which is accounted for by the groups. In addition, discriminant analysis programs typically report the percentage of the sample which is correctly classified using the discriminant function that has been derived.

D. Chapter Summary

The data for the current study were collected using both qualitative and quantitative approaches. The instruments and procedures for conducting the observations, interviews, and surveys were piloted and revised before they were used in the study. Qualitative data were gained principally from observations and interviews with three selected chemistry teachers working in three different school settings. The quantitative methods included developing and administering a Student Opinion Survey (SOS) to the students of the three teachers who were observed and interviewed. Each school site was visited five times over a period of four months. In addition, the Chemistry Classroom Practice Survey (CCPS) was developed and administered to a randomly selected sample of Alberta chemistry teachers. The survey sample was drawn by randomly selecting 50 high schools from the 242 Alberta schools which offer a complete high school chemistry program. CCPS questionniares were sent to all the chemistry teachers in the schools selected and completed questionniares were returned by 69 teachers, working in 37 different schools. The school return rate was 74% and the estimated teacher return rate was 61%.

The interview transcripts and the responses to the open-ended questions in the CCPS were analyzed by categorizing the statements as they related to the four curriculum commonplaces: chemistry, teaching, students, and school setting. Recurring themes were then sought within each of these categories. The numerical data were entered directly into a computer file and were analyzed using standard programs from the Statistical Package for the Social Sciences (SPSS) library (Nie et al, 1975).

IV. FINDINGS AND DISCUSSION

In this chapter the findings from the classroom observations and the teacher interviews are reported, discussed, and compared, and a presentation and discussion of the data captured by the Chemistry Classroom Practice Survey (CCPS) is given.

A. Three Selected Chemistry Teachers and Their Schools

In the following section the teaching situation and classroom practice of three chemistry teachers is described. The names of the schools; Parkland, Rutherford, and Glenview; are fictitious, as are the names of the teachers; Allan, Jensen, and Kurelek. However, the people, places, and situations are real, and care was taken to describe them accurately. The transcripts of the interviews with the three teachers are contained in Appendices G, H, and I. The names of persons and places mentioned in the transcripts have been altered or omitted to preserve confidentiality.

Parkland Composite High School

Parkland Composite High School is situated in a town of about 5000 whose economy is supported by agriculture and natural gas. The growth of the town has slowed in the recent economic recession, contributing to the declining enrollment of the high school. The 1982-83 enrollment of Parkland High School was approximately 600, with about 40 percent coming from the town itself, and the remainder coming from the surrounding farms and acreages. The brick, two-storey school building, constructed in the late 1960's, seems well designed and adequately equipped.

Parkland High School operates on a semester system and offers academic, business education, and vocational programs for grades 10 to 12. The vocational program, which serves the entire county, draws about forty additional students from outside the regular attendance area. While about three-quarters of the grade ten students are enrolled in an academic program, the proportion drops to about one-half by grade twelve. A survey completed for the regional principals' association indicated that 44% of the 1983 graduating class at Parkland High School went on to some form of post-secondary training.

The school's student handbook provides the following information about the chemistry program at Parkland.

> CHEMISTRY 10/20
> Pre-requisite: None initially
> Credits: 3 + 3
> This course is not open to Grade X students at Parkland Composite High School. Matriculation Chemistry students will do both Chemistry 10 and Chemistry 20 by treating the combined course like one 5-credit course in Grade XI. Topics include:
> Chemistry 10 - lab techniques; measurement; classification of matter; atomic theory; nomenclature; chemical reactions; stoichiometry.
> Chemistry 20 - solutions; bonding; organic chemistry; stoichiometry; lab techniques.
>
> CHEMISTRY 30
> Pre-requisite: 50% in Chemistry 20
> Credits: 5
> This is a Grade XII matriculation science course required for application to certain faculties. Topics include: heats of reaction; nuclear chemistry; acids and bases; electrochemistry; equilibrium.

It is interesting to note that the core-elective aspect of the Alberta chemistry program is not mentioned in the chemistry course descriptions at Parkland. The term *matriculation* used in the chemistry course description is also used in describing the physics program but not for the biology program, suggesting that the chemistry and physics programs in Parkland are intended for university-bound students, while biology is intended for a somewhat larger audience. The relative size of the enrollments in biology, chemistry, and physics, shown in Table 4, support this interpretation. In contrast to the university preparation orientation of the chemistry and physics programs, Science 11 is described as, "a terminal science course for the weak science student who intends to take no other science course in high school." The course descriptions suggest that the chemistry courses at Parkland High are regarded principally as part of a program of university preparation.

The school employs four science teachers, three males and one female. All of the science teachers at Parkland High teach other courses as well, since a decline in enrollments has meant a reduction in the number of science courses taught. The, "fairly high attrition rate in science courses", described by one of Parkland's administrators is reflected in the 1982-83 enrollment figures given in Table 4. The decline in enrollment in science courses over the 10, 20, 30 sequence is consistent with the shift away from

Table 4

Science Course Enrollments at Parkland High School

	Grade 10	Grade 11	Grade 12
Biology	130	90	70
Chemistry	85	90	50
Physics	110	65	40
General Science	80		

academic courses from grade ten to grade twelve.

Mr. Allan

Allan is in his early forties and has taught high school chemistry for nineteen years, all of them at Parkland. He holds a B. Sc. in chemistry and a teaching certificate (professional diploma after degree), and a graduate diploma in educational administration. Allan lives on an acreage near the town, and takes an active part in community affairs. He shares a small office with another science teacher. The office contains a chair, desk, file cabinet, and book case for each teacher. Allan's bookcase is filled with a variety of high school and university books on general science, chemistry, and mathematics, as well as two bound volumes of *Chem 13 News*. A large demonstration slide rule is propped against the wall, unused now since nearly all students have calculators. Allan has a portable microcomputer which he uses to keep student records and calculate student marks.

Allan teaches all his classes in the same second floor classroom, a tiered room equipped with movable student desks, a teacher desk, and a demonstration bench. The room is well equipped with blackboards, tackboards, projection screen, and shelves. A set of wooden cupboards contain a class set of the original edition of the CHEM Study text, and a smaller number of an earlier Chemistry 30 text, *Chemistry*, by Seinko and Plane. Commercial posters dealing with lab safety, nuclear energy and radiation, and upcoming science events are neatly mounted on the tackboards, along with newspaper and magazine clippings (articles and cartoons). His teaching assignment in the current semester involves one section each of, Chemistry 10/20, Chemistry 30, Science 11, and Mathematics 13. He also teaches an adult upgrading course in chemistry at a nearby junior college.

Allan manages his classes with practiced efficiency. Classroom routines such as reading morning announcements, handing out library notices, and collecting and returning assignments are dispatched quickly and effectively. In Allan's classroom, a typical chemistry lesson begins by sending selected students to the blackboard to write out their solutions to particular questions from the previous days homework. While this is being done, Allan moves around the classroom, looking at the homework of the remaining students, helping those who had difficulty, and admonishing those whose assignments are not completed. It seems that nearly all the students make a sincere attempt to complete their homework, and most are successful.

A general air of good humor pervades the classroom, with Allan teasing students about minor errors in their work. Even the routine of selecting students to put their homework on the blackboard is done with a touch of humor. In one Chemistry 30 class that I observed, some of the students had received library notices about overdue books. When they returned to the class, Allan told them, "We had a vote here and decided that the people with library notices should be the ones to put their homework on the blackboard."

Once the students are finished at the blackboard, Allan proceeds to check over each solution quickly and without comment, placing check marks on those that are satisfactory. When errors are found, the respective student is quizzed to see if he can identify the mistake. When the student locates the error, he returns to the blackboard to correct his work. Sometimes two or three attempts are made before the solution is satisfactory. The students at their desks are expected to check their homework against the solutions on the blackboard, and are encouraged to spot errors and raise questions about the solutions.

With homework out of the way the class proceeds to the next topic. Allan typically does an illustrative example of a calculation or a nomenclature problem, with students called on to help with the various steps of the process. Sometimes additional notes are given to supplement the text. Students are given class time to work on assignments, which are given from both ALCHEM and O'Connor for the Chemistry 30 class. For Chemistry 10 the assignments are mainly given from ALCHEM with some extra work sheets given which require consulting additional references kept in the room. There was no indication that the students questioned the value of any of Allan's teaching routines. They seemed to take them for granted as part of studying chemistry.

My initial interview with Allan followed the guiding questions outlined in Chapter 3. The major points that emerged in the interview are summarized here, by way of background information on Allan's classroom practice. Later in this section, the major themes that emerged from an analysis of the transcripts of all the interviews with Allan are presented and discussed. The observation notes from Parkland High School and the transcripts of the interviews with Allan are contained in Appendix G.

Allan has moved into using the ALCHEM materials gradually over the last four years, starting with Chemistry 20 and then moving into Chemistry 10 and 30. The 1982/83 term was the first year that he had used ALCHEM with his Chemistry 30 classes. During the initial interview Allan indicated that he felt that the ALCHEM materials were an excellent "assignment booklet", but that they were deficient in the explanations provided. He regards ALCHEM as, "a skeleton set of materials to work from", and would like to see, "a good textbook accompany the course", so that students could have ready access to additional reference material. Allan uses *Keys to Chemistry*, to prepare the required equipment and materials, the O'Connor revision of CHEM Study, and his own worksheets to supplement ALCHEM in all his chemistry courses. It became apparent in the first interview that time constraints were a major factor in determining Allan's choice and use of curriculum materials. There seemed to be three aspects to the time constraint factor; instructional time, preparation time, and turn around time on assignments. The influence of the time constraint factor on Allan's interpretation of curriculum materials is discussed in more detail later in this section, as they relate to the major themes in Allan's interpretation of curriuculum material.

Allan omits some of the ALCHEM labs because he feels that they are out of sequence with the topics being discussed. He also mentioned that not having a lab assistant made it difficult to do all the experiments and demonstrations included in ALCHEM, because of the time it takes. Although he has ready access to the County film library, he makes very little use of films, expressing the view, "a film, I think, is only good if it shows something that you can't do conveniently in the classroom". Allan indicated that, because of lack of time, he doesn't do any formal electives in Chemistry 10 and 20, but he does expand on the core topics throughout the course. In Chemistry 30, he does an elective unit on nuclear chemistry as well as covering reaction rates and equilibrium.

In subsequent interviews, the responses to the initial questions were probed for further information, and classroom observations were discussed along with the results of the Student Opinion Survey (SOS). Summaries of the opinion survey for Allan's classes are given in Tables 5 and 6. The mean and standard deviation of the student responses are given for each item on the SOS, and the fourteen aspects of ALCHEM are ranked in order of their mean rating for each of the three parts of the survey. In the discussions, the mean ratings were taken to be a measure of how useful or interesting the students perceived that aspect of the material to be. The standard deviation was taken to be an index of consensus, where a low value reflected agreement, and a high value indicated disagreement (Erickson & Nosanchuck, 1977). On the five-point rating scale used in the SOS, the maximum possible standard deviation is 2.0. In the following discussion of the SOS ratings the numbers in parentheses refer, respectively, to the mean and standard deviation of the item.

The discussion with Allan regarding the SOS summary for his classes focused on his interpretation of the students' ratings. The transcript of this interview, the fifth with Allan, is included in Appendix G. Allan indicated that the SOS ratings were generally consistent with his classroom use of the ALCHEM materials. They also seemed to be consistent with what I saw of Allan's use of ALCHEM in the classes I observed.

There was strong agreement among Allan's Chemistry 10 students that the periodic table contained in the ALCHEM 10 text was very useful for helping them gain an understanding of chemistry (4.8, 0.5) and for preparing for exams (4.4, 0.8). Allan was not surprised at these high ratings because of the extensive use he makes of the periodic table in his teaching. The worksheet on the film, "Chemical Families", and the lab on safety and efficiency in the laboratory received low ratings from all three points of view. The discussion with Allan revealed that he had used the film with the class *after* they had completed the SOS and the laboratory safety exercise had been incorporated into an introductory lab activity of his own design. This probably accounts for the low mean rating and the high standard deviation for these items, since students would be unsure how to respond to an aspect of the material that they didn't recall using.

Table 5

Summary of Student Opinion of the ALCHEM 10 Text

Mr. Allan's Chemistry 10 Class—24 Students

Rank		Mean	S.D.
	For Gaining an Understanding of Chemistry		
1.	periodic table provided in the ALCHEM 10 text:	4.8	0.5
2.	worked out examples of mathematical problems:	4.3	1.0
3.	explanations of chemical concepts and principles:	4.3	0.7
4.	worksheets which require completion of tables:	4.3	1.0
5.	overview exercises at the end of each unit:	4.2	1.0
6.	mathematical problems:	4.2	0.9
7.	demonstrations:	4.0	0.8
8.	lab work:	3.9	1.0
9.	information about sources and uses of chemicals:	3.8	1.0
10.	illustrations:	3.6	1.0
11.	objectives listed at the beginning of each unit:	3.1	1.2
12.	worksheet on the film, "Chemical Families":	3.0	1.2
13.	biographical sketches:	2.9	1.4
14.	lab on safety and efficiency in the laboratory:	2.8	1.0
	For Exam Preparation		
1.	worksheets which require completion of tables:	4.5	1.0
2.	periodic table provided in the ALCHEM 10 text:	4.4	0.8
3.	mathematical problems:	4.4	0.8
4.	overview exercises at the end of each unit:	4.3	1.1
5.	explanations of chemical concepts and principles:	4.1	1.0
6.	worked out examples of mathematical problems:	3.8	1.3
7.	information about sources and uses of chemicals:	3.5	1.3
8.	objectives listed at the beginning of each unit:	3.3	1.4
9.	demonstrations:	3.2	1.3
10.	lab work:	3.0	1.1
11.	worksheet on the film, "Chemical Families":	2.9	1.2
12.	illustrations:	2.8	1.1
13.	biographical sketches:	2.3	1.2
14.	lab on safety and efficiency in the laboratory:	2.0	1.1
	Interesting Information or Activity		
1.	periodic table provided in the ALCHEM 10 text:	4.0	1.0
2.	information about sources and uses of chemicals:	3.8	1.2
3.	mathematical problems:	3.6	1.1
4.	worksheets which require completion of tables:	3.4	1.1
5.	illustrations:	3.3	1.2
6.	demonstrations:	3.3	1.0
7.	worked out examples of mathematical problems:	3.3	1.1
8.	overview exercises at the end of each unit:	3.3	1.0
9.	lab work:	3.1	1.4
10.	biographical sketches:	3.0	1.5
11.	explanations of chemical concepts and principles:	3.0	1.2
12.	lab on safety and efficiency in the laboratory:	2.8	1.3
13.	objectives listed at the beginning of each unit:	2.6	1.1
14.	worksheet on the film, "Chemical Families":	2.1	1.1

Table 6

Summary of Student Opinions of the ALCHEM 30 Text

Mr. Allan's Chemistry 30 Class—29 students

Rank		Mean	S.D.
	For Gaining an Understanding of Chemistry		
1.	worked out examples of mathematical problems:	4.4	0.9
2.	worksheets which require completion of tables:	4.4	0.9
3.	periodic table provided in the ALCHEM 30 text:	4.3	1.0
4.	mathematical problems:	4.2	0.8
5.	ALCHEM data sheet:	4.1	1.1
6.	review of Chemistry 10 and 20:	4.0	0.8
7.	overview exercises at the end of each unit:	4.0	0.8
8.	explanations of chemical concepts and principles:	4.0	0.8
9.	lab work:	4.0	0.9
10.	demonstrations:	3.6	0.9
11.	illustrations:	3.5	1.2
12.	information about sources and uses of chemicals:	3.3	0.9
13.	objectives listed at the beginning of each unit:	3.2	1.1
14.	biographical sketches:	2.8	1.0
	For Exam Preparation		
1.	periodic table provided in the ALCHEM 30 text:	4.6	0.9
2.	overview exercises at the end of each unit:	4.4	0.8
3.	worked out examples of mathematical problems:	4.3	1.0
4.	worksheets which require completion of tables:	4.2	0.9
5.	review of Chemistry 10 and 20:	4.1	0.7
6.	ALCHEM data sheet:	4.0	1.2
7.	mathematical problems:	3.9	1.0
8.	objectives listed at the beginning of each unit:	3.9	1.0
9.	explanations of chemical concepts and principles:	3.2	1.2
10.	information about sources and uses of chemicals:	3.1	0.9
11.	illustrations:	2.9	1.1
12.	lab work:	2.8	1.1
13.	biographical sketches:	2.6	1.2
14.	demonstrations:	2.6	0.9
	Interesting Information or Activity		
1.	lab work:	4.1	0.8
2.	information about sources and uses of chemicals:	3.7	0.9
3.	explanations of chemical concepts and principles:	3.7	0.8
4.	worked out examples of mathematical problems:	3.6	0.9
5.	mathematical problems:	3.6	0.9
6.	worksheets which require completion of tables:	3.5	1.0
7.	demonstrations:	3.4	1.2
8.	overview exercises at the end of each unit:	3.4	0.8
9.	periodic table provided in the ALCHEM 30 text:	3.3	1.1
10.	illustrations:	3.3	0.9
11.	ALCHEM data sheet:	3.2	1.0
12.	biographical sketches:	3.2	1.2
13.	review of Chemistry 10 and 20:	3.1	0.9
14.	objectives listed at the beginning of each unit:	2.7	1.2

Allan's Chemistry 10 and 30 classes both rated the student exercises in ALCHEM, such as worksheets, and overview exercises, as being very useful for helping them gain an understanding of chemistry and prepare for exams. These student ratings are consistent with Allan's using the ALCHEM texts principally as assignment booklets. Allan accounted for the low rating of biographical sketches and information about sources and uses of chemicals by explaining that he does not stress them in class or put them on exams, but leaves them for students to read on their own. In general the students' ratings of the ALCHEM seemed to be a valid reflection of Allan's use of the materials in his classroom.

As the observation notes and interview transcripts were analyzed, some consistent themes emerged in Allan's use of the ALCHEM materials and in his comments on them. These themes seem to indicate major factors in Allan's interpretation of curriculum materials, and they clearly had a strong influence on how he translated the intended chemistry curriculum into practice in his classroom. These themes are discussed here as they relate to the following four areas: chemistry, teaching, students, and school setting. The themes that emerged in the observations and interviews are taken as a reflection of Allan's perception of these four "curriculum commonplaces" (Schwab, 1971).

Allan's classroom practice reflects a view of chemistry as a well established body of concepts, principles, and theories. There is no mention of chemistry as a developing field of study which can illustrate the nature of science. In one Chemistry 10 class he criticized the Bohr model of the atom because of its limited power to predict the energy levels for the transition metals, without acknowledging that restricted models and limited theories are widely used in chemistry. Allan seems to have a clear notion of what topics should be included in a high school chemistry program. In commenting on the ALCHEM materials, he faulted them because the section on equilibrium did not provide an adequate basis for teaching the equilibrium constants of acids, and he described the absence of any discussion of the gas laws as a "glaring omission". When I pointed out that these topics were not part of the core program as outlined in the Alberta chemistry curriculum guide, and asked why he chose to include them in his chemistry courses, he gave the following explanation:

Allan: Because of the use of equilibrium constants, your Ka's for acids are

> equilibrium constants. So I develop the idea of an equilibrium constant expression and manipulating that equilibrium constant expression and then went on to an application.
>
> **Lantz:** Okay, so it is. . . to treat the acid base chemistry rigorously. You need the background in equilibrium so that it is done to supplement.
>
> **Allan:** That's right. Plus the fact I never really had any quarrel with the topics chosen for the Chem 30 program before. It was a little bit long but I thought it was a good selection of topics. Even the way it was from the CHEM Study. You know you can argue about the quality of the CHEM Study text, but the actual selection of topics was good. I was actually sorry to see the section on solubility products taken out.

Allan regards chemistry as having important implications for everyday life in his community, as indicated by his stressing the use of organic compounds and relating it to the local natural gas industry. His views on the implications of chemistry for daily life are reflected in the following comments:

> **Allan:**. . . I am involved with PAL in a very minor way, it is the Preserve Agricultural Land Group, that was formed at the time of the (name omitted) plant being put up. And my comment here is that you can't afford to be scientifically illiterate because you are put under pressure by a lot of people that are smooth talkers and not necessarily very knowledgeable. It came to the point there the one meeting I was at they were squabbling over. . . not squabbling, that's not a good way of putting it. There has been some controversy over the change in the soil pH as a result of the Esso Plant that's east of (name omitted) there. And you get the two sides of it, one person saying that a pH change or a soil change by a pH of 1 that's a whole lot and the other that well it hasn't changed by 1 its only changed by .7 or .5 and its a very small change. At the meeting I pointed out, "What we are talking about here are pH changes of 1 as a tenfold change in acidity of the soil, and a tenfold change from the midpoint of high productivity for agriculture. You change that by tenfold and that puts you into the marginal". I said, "Now whether the 1.0 or the .5 are correct or not, we can argue about that", but I said, "There is this small number that you are talking about is actually a very significant change". I alluded it to your paycheque. I said, "you complain about a tenfold change in your taxes on your paycheck up or down". And this is what I meant by being scientifically illiterate. These are farmers. They never knew that this was going to come about. So my point is you have to know something and chemistry is part of being a person in our society.

As it relates to teaching, Allan's interpretive process seems to be characterized by a valuing of both pedagogical efficiency and academic rigor. Many of Allan's comments about pedagogical efficiency and academic rigor were made in the context of the time constraints he feels in teaching his chemistry classes. The value placed on efficiency is indicated by the handling of homework, lab reports, tests, and quizzes. During one Chemistry 10 class which I observed, quizzes on chemical symbols and lab equipment were given. Each quiz was written, marked in class, and returned to the students in less than ten minutes. This type of quiz is used to provide both motivation and immediate feedback to the students. The importance that Allan attaches to immediate feedback is also illustrated by the following comments he made about lab reports:

> **Lantz:** Do you require a full scale written up lab report?
>
> **Allan:** No I don't.
>
> **Lantz:** Oh, the ones that were being turned in last week what sort of format were they in?
>
> **Allan:** They were in a worksheet form. I find that I spend too much time marking. I'm using the one out of O'Connor rather than the ALCHEM because that's the kind of thing I've got laid out.
>
> **Lantz:** So it's a sheet to put your data down on.
>
> **Allan:** That's right. You can take that one with you. See, this is what I've done with this one too. I have laid out very specific spots for them to put their data on and then I've constructed a table that suggested they construct - the numbers here correspond to the numbers in the lab manual plus a question I've added. I find that I can mark this a lot faster. Now something like this I try to time it so that they do it finish it on one day I can take it home that night and mark it because the end conclusion here is the law of additivity of heats. I can fire this back to them the next day, discuss the experiment and in the process of discussing the experiment complete the development of the law of additivity of heats as I expect them to understand it as one continuous lesson. So I have to have that turn around. If I'm going to read an experiment where they have done procedure and written it all up in the past perfect tense as a formal lab should be. . . That's like marking essays. I don't think that it hurts that they do this. I can't make that turn around in time. I can't mark 30 labs. . . I like to make a turn around on a test or an assignment or anything. Turn it in today I'll have it back to you tomorrow.

Another indication of Allan's appreciation of pedagogical efficiency, was his concurrence with the students' high SOS rating of the Periodic Table for helping them understand chemistry (4.8 from the Chem 10's and 4.4 from the Chem 30's):

> **Allan:** I'm not surprised at the periodic table because you know every time you turn around you're drawing information off it. There's a lot of information (on it), the way that it's put together.

The valuing of pedagogical efficiency is consistent with the importance Allan places on sequencing of topics in the curriculum. Allan indicated that the main reason that he dropped the *Keys to Chemistry* text in favor of ALCHEM was that he didn't like the sequencing of topics in *Keys*. Inappropriate sequencing is also the reason he gave for omitting some of the ALCHEM materials. For example, he omits a student activity involving construction of molecular models which is part of the ALCHEM 10 unit on bonding because he feels that it deals with structural formulas which is part of the Chemistry 20 course.

In describing his way of handling the chemistry program, Allan used the terms, "bag of tricks", and "own pet way of doing things". In exploring the meaning of these terms with him, it seems that they reflected a repertoire of illustrations and approaches which he had developed over the years. These illustrations and approaches are valued because of their effectiveness demonstrating phenomena (e.g., preciptitation), illustrating theoretical models (e.g., chemical bonding), and outlining a problem solving approach (e.g., thermochemistry). In response to my question about what function his, "bag of tricks", played in his teaching Allan offered the following explanation:

> **Allan**: They come in to play, I suppose, as a result of the way the students respond to a particular situation. You know, somebody asks something and that immediately requires a certain kind of explanation and over a period of time you've put together a bunch of goodies. So that when the student asks a particular kind of question or has a particular kind of problem you can pull out some odds and sods that you can use to illustrate it.
>
> **Lantz**: Can you give me an example? Maybe I'm not quite understanding.
>
> **Allan**: Ah. . . I think in terms of. . . Physics, I suppose is one of the examples that comes most immediately to my mind. We're talking about when something is moving in a circle on the end of a string and you let it go it will take off in a straight line. You know, I happen to pull open my drawer and well I didn't have any string but I had a wire that had an alligator clip on the end of it that I'd use to hook to an electrochemical cell, well I took that and hooked a weight as. . . I think I pulled an iron ring out of the drawer, clipped it on the end of it and swung it around and said, "Okay". You know, we let it go and it took off at a 90 degree angle or whatever direction it was heading. Its just a collection of things that. . . You know, you get into an argument or discussion (and) you can pull something out that will illustrate it as a totally unplanned demonstration to a spontaneous question. So you need the things together. You can't pack that - you'd have to pack a whole drawer into a classroom if you were. You know, (if) your office and all your materials were in one place and you were teaching in somewhere else. I mean, I even run across into the hall - across over here, and somebody will say something and I say, "Well look just a minute". I can go and nip out and grab a beaker and grab something off the shelf and say, "okay".
>
> **Lantz**: Do these tend to be things that when the student is having trouble understanding a point or maybe is misunderstanding and these illustrations you've found to. . . to have clarified, to establish a concept or clarify the misconception?

Allan: That's right.

Lantz: That's the kind of. . . That's one function of the bag of tricks?

Allan: . . . the problem the students were having with that question (in the Chem 30 class). You know its something I hadn't anticipated, that they would have trouble calculating the amount of fuel needed to heat this up. And I drew an immediate analogy, I hope it was a close enough analogy, to taking a car down the road and how much gasoline do you need to put in the tank to get you a certain distance. Knowing your car consumes fuel at a certain rate. I'll tell you there was no - that analogy I pulled out that was quite original and I don't know if I'd say whether it fit or not.

Lantz: No, I think that it certainly fit in with the way that you were solving the problem on the board with ratios and in a logical sequence.

Allan: My bag of tricks in the drawer serves the same purpose.

Lantz: Okay. Sometimes I guess its function would be to present a model of a situation like - we don't do much with energy levels anymore but I guess that would be one thing where - we talk about electrons dropping from one energy level to another. CHEM Study used to have this bookshelf with the different levels in it and that kind of thing would fit into that by way of illustration.

Allan: That's right. What was it yesterday?. . . We were into a discussion on where energy went. You know you had potential energy and, what was it? Stabilizing process, I know, it was when bonds form. I said if bonds are going to stabilize or form and the atoms are going to stabilize I said they have to lose energy. If they are going to stick together, you know, two atoms if they don't lose energy they approach they hit that repulsive force and it throws them apart. I took the analogy and I reached in my drawer and I pulled out. . . I've got a steel ball in there that I've used for friction experiments, and a tennis ball. I dropped the two and I said, "The steel ball essentially hit the floor they stuck together, and how did they manage to do that where this other ball bounced?" Well, somebody said, "energy loss", and somebody else said, "well the steel ball is heavier so it won't bounce as high". So I went back to my drawer and I pulled out a styrofoam ball and I dropped the styrofoam ball and the rubber ball and I said, "Okay, the rubber ball is heavier and it bounced further, what happened?" Well somebody said, "elasticity", and then somebody said, "well the one lost its energy the other compressed it and retained it and they bounced apart".

Lantz: Okay, I'm glad I asked because I had a little different picture of what you meant by that. I was thinking of a little strip of magnesium ribbon that you might burn to illustrate a type of reaction and maybe some reagent bottles for showing some typical reactions. Is that part of the bag of tricks?

Allan: That's part of the bag of tricks, that happens to be around the corner in the lab, I'll have some left over solution from an experiment. The question will come up and I'll end up pulling some left over solution, or two or three of them, a handful of beakers and my jug of distilled water.

Lantz: And illustrate percipitation or that kind of . . .

> **Allan**: That's right, there is something that comes up. So that's part of the bag of tricks too, its just that it's ten steps across the hall it's not a five minute walk to the other end of the building or anything like that. Your perception there is correct.

The above comments seem to reflect a valuing of pedagogical potency, that is, being able to take advantage of "teachable moments" so that students get immediate feedback on their questions. It seems that this factor in his interpretive process leads him to use the ALCHEM worksheets while omitting many of the experiments, and demonstrations, and de-emphasizing the applied chemistry contained in ALCHEM. While he appreciates the ALCHEM materials for their pedagogical efficiency, Allan faults them for what he sees as a lack of rigor. The value that Allan places on academic rigor would seem to account for the thorough presentation and coverage he gives each topic as well as his insistence that students master chemical concepts and problem solving skills. His classroom practice has students drawing from a variety of sources for notes and exercises. The Chemistry 30 class is supplied with both the O'Connor text and the ALCHEM 30 materials, and students are given some assignments which require using texts kept in the classroom. In some ways the chemistry program that Allan's students are getting is an accretion of topics from all the chemistry programs that Allan has ever taught. With the large volume of content that Allan covers in his chemistry courses, it is not suprising that he feels there is inadequate time to cover the course and that he values efficient teaching strategies. Allan comments that more time should be allotted to the high school chemistry program.

> **Allan:** I think the whole (Chemistry) 10/20 program is too big. I think there should be a 5 credit (Chemistry) 10 and a 5 credit (Chemistry) 20 and a 5 credit (Chemistry) 30 to get an adequate level of courses in. I have omitted some of the labs in the past and (now) I am working more in.

The trade off between pedagogical efficiency and academic rigor is evidenced by Allan's attitude toward problem solving in the ALCHEM program. Although he appreciates ALCHEM as a source of exercises, he does not like the routine use of mathematical formulas in the sample solutions (worked examples). He prefers to use a method he calls, "dimensional analysis", in which the units on the quantities serve to guide the calculations. Allan has tried the "formula approach", but feels that students perform the mathematical manipulations without thinking about them, and has returned to using dimensional analysis.

It might seem that Allan was modifying the ALCHEM materials to better accomplish one of the stated goals of the Alberta chemistry program (i.e., objective 1.3, "skill in individual and group problem solving"), because he believes that his approach is a more effective way of meeting this objective. However, Allan's motivation for using the dimensional analysis approach seems to come from his own conviction about effective chemistry teaching, rather than from striving to meet an objective in the curriculum guide.

The good rapport that Allan has with his students indicates that he generally enjoys working with them. The academic rigor that he expects of his students indicates that he feels that students are capable of meeting a challange and growing from it. When I asked Allan about the practice of having students find their own errors and correct them when they put their homework on the blackboard, he offered the following explanation:

> **Allan**: Well, I like them to do a bit of searching on their own. I say, "okay, you've made a mistake come back up here and let's go to work on it again, look for a fault." At a point I'll come along and I'll discuss it with them because I look at a student going to the board. They put a question on and they've got no trouble, fine go sit down and you've got the satisfaction that the job is good. On the other hand, as I go down the board, I will - when I discuss a question I sometimes have them put their names on - other times I'll look at a question and I'll turn around and I'll say, "Okay, well, who am I talking to?" You know, "who did this question?", and so somebody will stick up their hand and I'll talk to that person about their question and we will have a discussion. I expect everybody else to be listening and sometimes you have trouble getting this message across but it is something that I do with all my classes that I talk to that person and I consider them - they volunteered so this is their individual help session the rest of you can listen to what we are doing - we're through you can ask about it or take part in that conversation, but I like to address that student.

Allan likes to challenge his students and then encourage them to succeed. "You're all smart, you wouldn't get here if you weren't", is a statement that Allan made to encourage his Chemistry 30 class when they were having trouble with a thermochemistry problem. He feels that students are looking for more background information and that is a reason that ALCHEM has to be supplemented. His insistence that assignments be turned in on time and that missed exams be written at noon hour further supports the view that he regards students as capable of serious work.

The following exchange between Allan and one of his Chemistry 30 students illustrates his view of students' capacity to handle a challenge.

> **Allan:** What's the name of this one, Don?
> **Student:** 2-methylhexane
> **Allan:** (walking toward student) Are you sure?

> **Student:** Well. . . Uhm. . . .
> **Allan:** Don! Are you sure?
> **Student:** Uhm. . . No.
> **Allan:** Don! How long is the carbon chain?
> **Student:** Six
> **Allan:** Right, so its hexane, and what's the side chain?
> **Student:** Methyl
> **Allan:** Right, and where is it attached?
> **Student:** On the second carbon.
> **Allan:** So, 2-methylhexane is right! You followed the rules and it is right. Speak with confidence!

Allan's concern for students is reflected in his modification of the ALCHEM materials to emphasize theoretical chemistry, so that students will have an easier time in post-secondary chemistry courses. Preparing students for post-secondary programs was the reason that Allan gave for teaching equilibrium topics in his chemistry classes.

> **Allan:** A lot of these students are taking Chemistry 30. By the time you get that far they are heading for some other place. It may not be necessarily a chemistry field but some of it requires chemistry as an entrance requirement. So you are dealing with a lot different groups than what you've got at the 10 level or even, mind you, by the time they get to the 20 level. Even they are pretty well oriented in an academic route.

Allan's emphasis on theoretical chemistry topics for the sake of students in, "an academic route", is consistent with the description of Chemistry 30 as, "a Grade XII matriculation science course required for application to certain faculties", in the Parkland student handbook. His interest in the SOS responses indicates that he takes student opinions seriously, expressing particular interest in student opinions about his demonstrations. He also cited student boredom with films as the chief reason he doesn't use them more frequently.

The school setting in which Allan teaches seems to have a considerable influence on how he interprets curriculum materials. The lack of a lab assistant is a major factor in determining how Allan interprets the student laboratory exercises in the ALCHEM materials.

> **Allan:**. . . we don't have teaching assistants here or lab technicians so it's up to the individual staff to prepare their own labs, and if you have got to go looking for these labs you spend an awful lot of time because you have 15 or 16 different stations to set up. It's not a matter of half a dozen solutions that everybody draws upon. You've got 16 stations and it's time consuming if you have got to round up all the different materials. They are good labs and I am working more of those in but I am going to have to set it up so that they are in boxes and when I come to Lab C1, there is the box and here is my ENO, and Draino and Saniflush and the whole bit, and I can set them out.

> **Lantz:** Yes, I can see that being the case, the school that I used teach at has had lab assistants so we haven't had that problem. The first time through the lab assistant had to do a lot of work to get these set up, but once they were in place it was fairly straightforward. So a factor then from your point of view is just how much time it takes to set up some of these labs?

> **Allan:** That is right, this is where the college has been good for me. We are working into the (ALCHEM)10, last year was the first year we really used the (ALCHEM)10. The year before was the first year we used the 20 in the ALCHEM materials completely. There of course, they have a lab assistant, I specify what lab I am going to do and she has all the materials and it is laid out. So I have tried labs that I haven't tried before and now that I found out how good they are and I am working them back into my system (at Parkland).

Again, the time demands of setting up the labs on his own is a major factor in determining how the labs are to be used.

In addition to the instances of applied chemistry in his local community, which Allan uses in his classes, the interviews with Allan indicated a keen awareness on his part about society's need for trained scientists and technologists.

> **Allan**:. . . one of the instructors that I was talking to at the College - I have known him for quite a number of years- was commenting about this aspect of concern in the States and the fact that they are coming through now with a generation of high school students that are being taught their chemistry, or math, or physics in high school by teachers who had one physics or science class in high school went on to other levels of study and they are teaching, and somebody has to teach the sciences and somebody gets assigned the job. They are not anywhere near qualified and the article that he had read expressed a great deal of concern over the fact that we're bringing up a whole generation of people that possibly wouldn't be able to handle the technology that we have developed at this point. The science oriented people are going into industry where the pay is better.

In a student handout called, "Why Study Chemistry?", Allan stresses the value of scientific literacy in contemporary society.

The following points summarize the information that was gleaned from the observations and interviews with Allan concerning his perceptions of chemistry, teaching, curriculum, and school setting. These perceptions seem to be based on beliefs and values which have a strong influence on how Allan interprets curriculum materials for use in his classroom.

1. Chemistry is perceived as a well established body of concepts, principles, and theories. From this body of knowledge, there is a definite set of topics which should be included in a high school chemistry program. These topics include; gas laws, reaction rates, and chemical equilibrium; topics which are not currently part of

the core program as outlined in the Alberta chemistry curriculum guide. The topics in the list seems to come from previous chemistry programs that Allan has taught and from what he believes will be required of his students in subsequent chemistry courses. Chemistry is also perceived to play an important role in everyday life, and examples of applied chemistry drawn from the local community should be included in high school chemistry classes.

2. Academic rigor and pedagogical efficiency are perceived as important components of teaching. Students should be given a thorough presentation of each topic in the chemistry program. Use of multiple texts is an effective way of providing adequate background to the students. ALCHEM is not a textbook because it doesn't give enough background information, especially on chemical theory. The teaching techniques of doing illustrative examples while questioning students for each step of the solution and having students put their solutions to homework assignments on the blackboard are valued by Allan, and have become part of his classroom routine. Another part of Allan's classroom routine is his, "bag of tricks", a repertoire of illustrations and examples which he has found to be effective in getting students to understand the chemical concepts presented.

3. Students are perceived to be capable of handling demanding academic work and will benefit from the experience. For example, students should be trained to think their way, logically and systematically through chemical calculations. In this respect, dimensional analysis is regarded as superior to substituting into formulas as a problem solving technique. Efficient teaching techniques should be used to make the best use of the limited time available for teaching chemistry. This factor needs to be balanced against the thorough and rigorous presentations mentioned earlier.

4. The local school setting is seen as inhibiting extensive student experimental work, because of the time required to prepare the necessary materials with out the services of a laboratory assistant. The larger society is perceived as requiring trained science specialists as well as a scientifically literate general population. In high school chemistry teaching, chemistry should be related to students everyday life, so that we produce a scientifically literate society.

Rutherford Composite High School

Rutherford Composite High School is a large urban school, housed in a brick and concrete building constructed in the late 1950's, and located in the vicinity of an affluent, professional residential district. The student population during the 1982-83 school year was approximately 1600, drawn from an attendance area which reflects a broad spectrum of socio-economic conditions. Figures from a local school board report show the following percentages of Rutherford's 1983 graduating class (582 students) enrolled in three local post-secondary institutions: university, 30.1%; institute of technology, 14.6%; and community college, 8.6%. As these figures indicate, a relatively large proportion of the students at Rutherford plan to attend university, and this intention is reflected and reinforced in the school's course offerings which are largely academic and include the requisite courses for the full International Baccalaureate (IB) program. An administrator that I interviewed indicated that there was considerable parental pressure on students at Rutherford to enroll in an academic program and considerable parental concern over student achievement.

The following chemistry course descriptions given in the program book:

> CHEMISTRY 10 (3 cr)
> Chemistry 10 is the study of compounds and the interaction of these compounds. Chemistry 10 deals with the structure of the atom, chemical formulae, balancing chemical equations, the mole concept and the mathematics of chemistry. Laboratory work accompanies the study of each of these topics. Mathematics basic to Chemistry will be taught.
>
> CHEMISTRY 20 (3 cr)
> Chemistry 20 examines the following topics: Chemistry 10 review, solution chemistry, the mathematics of solution chemistry, chemical bonding and organic chemistry. Laboratory work accompanies each of these topics.
>
> CHEMISTRY 30 (5 cr)
> This course consists of a short review of Chemistry 20, followed by a study of; chemical energy, oxidation - reduction reactions and acid - base reactions. The material studied is closely integrated with laboratory investigations, optional units of interest are studied at the conclusion of the core material.

The description for each chemistry course consists of a listing of the unit titles in the corresponding ALCHEM texts, suggesting that the chemistry program at Rutherford is synonomious with the ALCHEM program. The statement in the Chemistry 30 description that "optional" units will be studied when the core is completed, is an indication that the elective part of the Chemistry 30 course is regarded as secondary to the core. It is also noteworthy that none of the possible elective units are listed. From the course descriptions it seems that lab work is considered to be an integral part of the chemistry program.

There are 11 teachers in the Science Department at Rutherford High, ten males and one female, and two full-time lab aides, both female. One of the male teachers is designated as Science Department Head, and another one as Assistant Department Head. Most of the courses at Rutherford High are offered on both a full year and semester basis. The school's program booklet includes the following description of the science program:

> The natural science program at Rutherford is offered in order that students may acquire understanding of the effect of science on everyday life. It is hoped that the program will help in the development of critical thinking and in applying scientific inquiry.

Table 7 gives the approximate enrollments in the science courses offered at Rutherford. Enrollment in the IB science courses are included with the figures for the corresponding regular science courses. The relatively low enrollment in Science 11 compared to the other grade 10 science courses indicates that most grade 10's at Rutherford enroll in an academic program. The sharp drop in enrollment between the 10 and 20 level science courses suggests that many students do not continue in an academic program after grade 10.

Mr. Jensen

Mr. Jensen is in his mid-forties and has fifteen years of teaching experience, all in the same system. He has been teaching continuously since he completed a B. Ed. degree, majoring in physical science, following a term in the Canadian airforce. He is an active member of the city's "oldtimers" hockey league and supervises the noon-hour hockey games which are part of the intramural program at Rutherford. His teaching assignment for the current semester consists of two sections each of Chemistry 10 and 30, and one section of Physics 10. The two semestered classes of Chemistry 30 offered in the school each semester, are a regular part of Jensen's teaching assignment.

Table 7

Science Course Enrollments at Rutherford High School

	Grade 10	Grade 11	Grade 12
Biology	550	300	300
Chemistry	500	410	300
Physics	300	240	150
General Science	100		

All Jensen's classes are taught in the same mainfloor classroom, a tiered lecture room equipped with a demonstration table, movable student desks, blackboards, tackboards, projection screen, shelves, and windows with blackout curtains. The chemistry lab is next door. Wall charts of the ALCHEM periodic table and data sheet are mounted in the classroom. There is a notice on the side blackboard advertising the CBC radio program, "Quirks and Quarks". Posters on the metric system, the CBC program, "Nature of Things", are mounted on the tackboards and a number of "bumper sticker" slogans are pasted on and around the demonstration desk (e.g., "warning - I have a low activation energy", and "a mole is a chemist's best friend"). Jensen and the assistant department head share workspace in a chemistry storage room adjacent to the laboratory. In addition to chemicals, the storage room contains several shelves piled high with supplementary worksheets for each unit of the high school chemistry program, representing the pooled efforts of Rutherford's chemistry teachers. Jensen also uses the staff lounge and the Science Department workroom for marking and lesson preparation.

Jensen has excellent rapport with his students and good natured bantering pervades his classes. In one of the classes I observed, Jensen had an arm wrestling competition with one of the boys before the class started (Jensen won). Through the informal atmosphere there is a general sense of work being done and of student interest in chemistry. The student ALCHEM materials are the focus of the chemistry instruction in his classes. Students are given reading and homework assignments from the student text, and the lectures are designed to complement the treatment given in ALCHEM. In his explanations, Jensen focuses on explaining a topic until the students understand the principle involved. He stresses points that students typically misunderstand (e.g., "not a 'fluoride atom, 'fluorine', 'ine' "), simplifying the ideas and often using a colloquial approach (e.g., "What's the world's most famous ionic compound?") After a careful explanation of the topic at hand, the students are given time to work on the relevant exercises in the ALCHEM materials, with Jensen providing personal assistance to the students who are having difficulty. Worked out solutions to the problems in the current unit are posted at the back of the room, and many students avail themselves of the opportunity to check their work. During these work periods the students give varying degrees of attention to the task, most working diligently, some socializing freely. There is a general air of industry and even some of the socializing is mixed with a discussion of the assigned chemistry (e.g., "I got a drink of H_2O.", and "What's the formula for a chocolate bar?").

The first interview with Jensen focused on his use of the ALCHEM materials in his classroom, following the guiding questions outlined in Chapter 3. The main points in Jensen's description of his use of ALCHEM are summarized here by way of providing background information on his classroom practice. The major themes which emerged in the three interviews with Jensen are described and discussed later. The observation notes from Rutherford High School and the transcripts of the interviews with Jensen are contained in Appendix H.

Jensen has been using the ALCHEM materials since the first editions were piloted and he generally likes them. He particularly appreciates the large number of student exercises which are incorporated into the textual materials. He noted that students occasionaly complain about there not being enough explanation in ALCHEM, but he would hate to see the materials, "made more verbal". He commented that it was good to leave some of the explaining to the teacher and hoped that the explanations would be kept brief in any future revisions of the ALCHEM materials. Jensen was involved in piloting some of the early versions of ALCHEM, was an active participant in the feedback sessions which were part of the meetings of the Edmonton Regional Chemistry Council at that time, and worked on developing an ALCHEM test item bank for the EPSB. Jensen's involvement in the ALCHEM project is reflected in his use of the pronoun, "we", when discussing the development of the materials.

Jensen indicated that he feels very rushed when teaching his chemistry classes, particularly Chemistry 10. He attributes the difficulty that he experiences in finishing the Chemistry 10 course to having students in the course who don't have the necessary ability.

> **Jensen**: Well, no, we have Science 11 too. I think that so many of the kids go into Chem 10; for various reasons, you know it's, "Let's get into the academic if we can." Also, perhaps to some extent the school has a reputation as an academic school and if you go to Rutherford you should be taking Chem 10 not Science 11. The emphasis is on that sort of thing. I have really had some students in Chem 10 that are not even close. There is just no way they can handle the material, but yet they are there. You do tend to be held up quite a bit by these types of students because you are trying to wait for them and you are trying to help them and in the meanwhile the other students are chomping at the bit to get going. I think I tend to be held up too much, I keep saying to myself, time and time again, "okay, this time in Chem 10 I have to push through those Units A, B and C, much quicker", but it always seems that by the time I hit (Unit) E I am just about out of time.
>
> **Lantz**: Now in Chem 10, there is no attempt in this school to screen the students? So you get a Chem 10 class and it is a mixed bag?
>
> **Jensen**: Oh yes, oh yes certainly a mixed bag. You get the total range here. You get those at the very bottom end. In other schools they might be taking more vocational or business ed. subjects. Then you get the top of the line students which is great and they can take 10, 20 and 30 in one semester. That's why the IB program was started here for those types of students. But you still get some of those in your normal Chem 10 classes, you know but. . .

Jensen's comments are consistent with those of an Assistant Principal at Rutherford who indicated that high academic achievement was an expectation of many parents in the community. Jensen feels that time constraints force him to make some trade-offs in the way he uses curriculum materials in his classroom. He points out the dilemma of having to choose between doing lab work and stressing content.

> **Jensen**:. . . there is such a scramble in the Chem 10 to get through the whole course. . . . if I see that I am being pressed for time, I leave out some of those labs. I don't like to, and I have to weigh one against the other. You know, is it better to use up the lab time and make sure that you get through Unit E properly?

Jensen omits some of the student experiments in ALCHEM 10 and 20 because he is pressed for time to complete the courses, and because he feels that students don't gain that much from some of them (e.g., the molecular model labs which use "tinker toys"). Jensen seems to regard classroom presentations as more effective than laboratory work in teaching the major concepts of chemistry. Since the school has two full time lab assistants, the time required to prepare the materials and equipment for student laboratory work is not a problem. Rather, it is the loss of instructional time which prevents him from doing more laboratory work with his students.

While an adequate presentation of the core topics in the Chemistry 10 and 20 courses takes up most of the instructional time, he is not as rushed in the Chemistry 30 course and can do justice to the core topics and cover at least one elective unit as well. Jensen points out that teaching Chemistry 30 under a semester arrangement allows time for only one elective unit, while teaching the same subject under a full-year arrangement allows time for two or three electives. His selection of elective units always includes nuclear chemistry, which is done by all the Chemistry 30 classes at Rutherford and is covered on the school's common final exam. He supplements the ALCHEM text with a number of CHEM Study and nuclear energy films from the school system's film library. He also has a number of his own demonstrations that he uses at points throughout the course, as well as supplementary work sheets, from a common departmental pool of teacher-made materials. He feels that he adapts the ALCHEM materials on a daily basis, trying to bring in current and local items as much as possible.

The summaries of the SOS responses for Jensen's classes are given in Tables 8 and 9. Jensen indicated that his students' ratings of the ALCHEM materials were generally consistent with the way he used them in his classes. He commented that the relatively low ratings the students gave to lab work, in both Chemistry 10 and 30, probably reflected their disappointment with the small amount of time actually spent in the lab. In his view, the time for lab work is often pre-empted by class work.

> **Jensen:** . . . I think kids generally in chemistry are disappointed in that they don't get to fool around more with chemicals. . . they have an idea that when they go into chemistry. . . "Boy, all this lab and chemicals and we get to put all these chemicals together and make all these nice things." . . . I think they get disappointed and they find that most of their work is class work; it's not lab work. I think this is not a fault with ALCHEM. Any chemistry course, in fact, I think my experience with ALCHEM and with the CHEM Study, there is actually more emphasis on lab work in ALCHEM than there is in the CHEM Study. . . I think there is less lab work than we would like to admit to when we write up the course description. . . There is lab work but not as much as the kids would like to see. I think the teachers are kind of stuck with it. . . We have got to get through a certain amount of material.

Table 8

Summary of Student Opinions of the ALCHEM 10 Text

Mr. Jensen's Chemistry 10 Classes—42 students

Rank	For Gaining an Understanding of Chemistry	Mean	S.D.
1.	periodic table provided in the ALCHEM 10 text:	4.6	0.7
2.	worksheets which require completion of tables:	4.3	0.9
3.	worked out examples of mathematical problems:	4.1	1.0
4.	explanations of chemical concepts and principles:	4.1	0.6
5.	mathematical problems:	3.8	0.8
6.	lab work:	3.8	0.9
7.	demonstrations:	3.8	1.1
8.	overview exercises at the end of each unit:	3.8	0.9
9.	information about sources and uses of chemicals:	3.6	1.1
10.	illustrations:	3.4	1.3
11.	objectives listed at the beginning of each unit:	3.3	1.2
12.	worksheet on the film, "Chemical Families":	3.2	1.1
13.	lab on safety and efficiency in the laboratory:	3.0	1.1
14.	biographical sketches:	2.5	1.1
	For Exam Preparation		
1.	periodic table provided in the ALCHEM 10 text:	4.5	0.9
2.	overview exercises at the end of each unit:	4.2	0.9
3.	worksheets which require completion of tables:	4.0	0.9
4.	explanations of chemical concepts and principles:	4.0	1.0
5.	worked out examples of mathematical problems:	4.0	0.8
6.	objectives listed at the beginning of each unit:	3.9	1.0
7.	demonstrations:	3.7	1.2
8.	information about sources and uses of chemicals:	3.6	1.0
9.	lab work:	3.5	1.1
10.	mathematical problems:	3.5	0.9
11.	worksheet on the film, "Chemical Families":	3.0	1.1
12.	biographical sketches:	2.7	1.2
13.	illustrations:	2.6	1.2
14.	lab on safety and efficiency in the laboratory:	2.1	1.0
	Interesting Information or Activity		
1.	periodic table provided in the ALCHEM 10 text:	3.5	1.1
2.	lab work:	3.4	1.0
3.	explanations of chemical concepts and principles:	3.2	0.9
4.	information about sources and uses of chemicals:	3.2	1.0
5.	demonstrations:	3.2	1.2
6.	worked out examples of mathematical problems:	3.2	1.2
7.	mathematical problems:	3.0	1.0
8.	worksheets which require completion of tables:	2.9	1.0
9.	biographical sketches:	2.8	1.3
10.	overview exercises at the end of each unit:	2.8	1.0
11.	illustrations:	2.7	1.1
12.	objectives listed at the beginning of each unit:	2.5	1.1
13.	worksheet on the film, "Chemical Families":	2.4	1.2
14.	lab on safety and efficiency in the laboratory:	2.3	1.2

Table 9

Summary of Student Opinions of the ALCHEM 30 Text

Mr. Jensen's Chemistry 30 Classes—36 students

Rank		Mean	S.D.
	For Gaining an Understanding of Chemistry		
1.	worked out examples of mathematical problems:	4.3	0.7
2.	ALCHEM data sheet:	4.1	0.9
3.	periodic table provided in the ALCHEM 30 text:	4.1	0.9
4.	lab work:	3.9	1.0
5.	worksheets which require completion of tables:	3.8	0.9
6.	mathematical problems:	3.8	0.9
7.	review of Chemistry 10 and 20:	3.7	0.9
8.	overview exercises at the end of each unit:	3.6	0.8
9.	explanations of chemical concepts and principles:	3.6	0.8
10.	information about sources and uses of chemicals:	3.5	0.9
11.	demonstrations:	3.4	1.0
12.	illustrations:	3.2	1.1
13.	objectives listed at the beginning of each unit:	2.8	1.1
14.	biographical sketches:	2.5	1.1
	For Exam Preparation		
1.	worked out examples of mathematical problems:	4.3	0.7
2.	overview exercises at the end of each unit:	4.0	1.0
3.	periodic table provided in the ALCHEM 30 text:	4.0	1.0
4.	ALCHEM data sheet:	4.0	1.0
5.	mathematical problems:	3.7	1.0
6.	review of Chemistry 10 and 20:	3.6	0.9
7.	worksheets which require completion of tables:	3.2	1.2
8.	objectives listed at the beginning of each unit:	3.2	1.2
9.	explanations of chemical concepts and principles:	3.1	0.9
10.	information about sources and uses of chemicals:	2.9	1.0
11.	lab work:	2.9	1.0
12.	illustrations:	2.7	1.0
13.	demonstrations:	2.4	1.1
14.	biographical sketches:	2.0	0.9
	Interesting Information or Activity		
1.	lab work:	3.8	1.1
2.	information about sources and uses of chemicals:	3.7	0.9
3.	explanations of chemical concepts and principles:	3.5	1.0
4.	mathematical problems:	3.5	1.0
5.	periodic table provided in the ALCHEM 30 text:	3.4	1.2
6.	demonstrations:	3.3	1.2
7.	worked out examples of mathematical problems:	3.3	1.0
8.	worksheets which require completion of tables:	3.2	1.0
9.	ALCHEM data sheet:	3.2	1.2
10.	overview exercises at the end of each unit:	3.2	1.1
11.	review of Chemistry 10 and 20:	2.9	0.8
12.	illustrations:	2.9	0.9
13.	biographical sketches:	2.8	1.3
14.	objectives listed at the beginning of each unit:	2.4	1.1

The high rating that his students gave the ALCHEM periodic table ((4.6, 0.7) for the Chem 10's and (4.1, 0.9) for the Chem 30's) did not surprise Jensen because of the emphasis he places on it in his day-to-day teaching and its function as an organizer of chemical facts.

> **Jensen**: . . . I really emphasize it. I really do in Chem 10 too. I tell them, "Know the periodic table. You won't have to memorize it but know what is on it." I keep emphasizing, "Know what is on it." And when I come to Unit A exam, I throw little questions on it like, "What year was a chemical discovered?", and "What's the boiling point?", without really covering it in class. Most of the kids get it. A lot of kids are caught. They don't know where to look. I point out a few things but I really emphasize, "Know what's on it, know what to find on that periodic table, look over all the information it says. Study it. Always on a Unit A exam, these are some of my questions. Like, "What's the boiling point?", "When was it discovered?", "Who discovered it?". And all of a sudden, "How are we supposed to know that? You expect us to memorize all that stuff?!" When they find out it is on the periodic table they get sort of mad at themselves and kind of mad at me, too, because I tricked them. But I didn't really. I really put a lot of emphasis on the table and knowing how to use it. I think it is quite important. It's much more important to me than just memorizing. I remember when I took Chem 10 in high school, we weren't allowed a periodic table so we had to kind of memorize certain things about it.

Jensen felt that the low ratings given to biographical sketches ((2.5, 1.1) for both Chem 10 and Chem 30) was due to his not stressing them in class. He indicated that lack of time prevented him from dealing with the biographies of scientists and uses of chemicals which are found in the ALCHEM materials.

> **Jensen**: Yes, I think so. The same with the biographies I don't really spend time on it. I just assign it, tell the kids to read it. I may mention it in passing but I don't stress it. I remember you were doing biographies quite a bit in ALCHEM. First, you had the sketches, biographies over at (name omitted). . . Remember, this whole book on biographies?
>
> **Lantz:** Yes, that's right. Asimov.
>
> **Jensen**: Yes, Asimov. That's good, that's a good one. I would like it. I find that quite interesting, yet I find that I just can't take the time. Especially the Chem 10 course, I really have difficulty getting through to the end of Unit E by the end of the semester.
>
> **Lantz**: That's certainly a factor with the Chem 10 course.
>
> **Jensen**: You rush and a few things you leave out. Like, you don't spend a lot of time talking about the sources and uses of chemicals. You don't spend a lot of time talking about scientists. You don't. You just assign it for the kids to read for homework or whatever and you go on to explain how to write formulas, how to write equations.

He expressed some surprise that his Chemistry 10 classes had rated the, "explanations of chemical concepts and principals" as high as they did for understanding chemistry (4.1, 0.6), and for exam preparation (4.0, 1.0), because some students had complained about the inadequacy of the materials in that regard. The relatively low ratings his Chemistry 30 class gave to demonstrations ((2.4, 1.1) for exam preparation) surprised him because he uses all the ALCHEM demonstrations and considers them effective and interesting.

> **Jensen**: Demonstrations aren't rated as high. I think the demos are pretty good in that Chem 30 course. Of course, I'm doing it so I am interested in them. The kids are just watching me and they are bored. I like the demos especially at the 30 level. Especially that redox one and the acid/base demos. I think that is good stuff yet the kids rated it quite low. Again, you see, I'm doing it. I think it is good. They are watching me so they get bored. If they did it themselves they'd probably think, "Hey, this is great."

In the discussions with Jensen some consistent themes emerged in his interpretation of the ALCHEM materials. These themes are discussed as they relate to chemistry, to teaching, to students, and to the school setting.

Jensen seems to view chemistry as a large and complex body of facts and principles. This view is reflected by his frequent references to chemistry as a body of "material" which has to be "gotten through". Jensen makes a point of telling his students that it is sometimes necessary to use incomplete explanations in the study of chemistry, in order to cope with this large body of material.

> **Jensen**: Yes, some of them get pretty restless. It's the same with that redox one where you do the redox on those four solutions. I do it over two days: two of them one day and two of them the other. I always save the sodium chloride for the last because they all work out beautifully and then all of a sudden it doesn't work out right. I think that stuff is great.

> **Lantz**: How do you do that then? Do you say, "We have a system here and we can predict what is going to happen"?

> **Jensen**: Yeah, and then you get to the sodium chloride and there is something wrong. We emphasize, "Hey, there is something wrong here." I check to make sure no gas leaked out because they've all done it, they know that hydrogen and oxygen should be produced. We get a gas on one side and not on the other. I lead them on saying that maybe the thing is leaking. Something really went wrong and then its, "Ha ha on me, I've messed up on the demo."

> **Lantz**: How do they take that when you get to the point that the system just doesn't work?

> **Jensen**: Most of them just accept it. There are a few arguments. I've got a couple of students in that period that are good students. They are really working on the fact that not everything works out the way it's supposed to. They start kidding me. Like when we did the redox one where we have to do the equations differently than the lab before. Then in acids and bases, we start writing acids and bases differently than we did in (Chemistry) 20. They ask me, "How many more times are you going to be lying to us?" "Are you sure this is the way it is going to be now?" And I'll say, No, probably when you get to university you might run into different ways of looking at it. Not the wrong way, it is just a more complete way of looking at it. They come to accept this pretty good. The fact that something doesn't work out, like, I say, "One of the nicest things about chemistry is all the rules. One of the nicer things about chemistry is all the exceptions to the rules."

Implicit in Jensen's comments is the idea of retricted models or theories, and in his own way Jensen is helping his students acquire an appreciation of this aspect of the nature of science.

Jensen views chemistry as very much part of everyday life and he frequently incorporates examples from the local chemical industry to his classroom presentations.

> **Jensen:** I always challenge the kids. . . "You see how important it is that the Fire Department knows, especially in a place like Edmonton's Chemical Row, that they know what chemicals are there. Because. . . they have to know what kind of fire extinguisher to use".

Some of the most influential factors determining Jensen's interpretation of curriculum materials are related to his views of teaching and the role of the teacher in determining the use of curriculum materials. Jensen maintains that curriculum materials need not be a complete course since the teacher can fill in missing information.

> **Jensen**: . . . as we saw in the class this morning - some of them saying that the information doesn't explain enough. I don't hear that too much from students - occasionally. You just can't explain everything, I think it becomes too wordy, and I think if you try that the kids get turned off on it. It gets too wordy there is just too much space in there of just words. I think, really, a brief explanation is sufficient and then leave the rest up to the teacher. This might be harder for teachers maybe in various areas that are not that familiar with chemistry, you know like maybe some other country places where more explanations in the book are necessary. But I think in general, as I said to the kid this morning, he made me feel useful. As a teacher you can fill in. I really think it's good if the kids read the notes and it leaves them with questions. If they come to class and they say "Hey, there is something in here that I didn't understand. It doesn't explain it quite right". I think that is a great learning process, of not trying to explain everything in the notes. Leave something up to the teacher to fill in. I think that is a good way of doing it and I would hate to see it more verbal. If I remember, the CHEM Study material was very verbal. And just to such an extent that an average kid just. . . got turned off for all the words. Where I think we purposely tried to make ALCHEM explanations as brief as possible. Just a bare outline of explanations. And then depending on the class. . . You see some kids need no explanations some need a lot more. Leave it up to the kids to read it and ask you, and question you in class. Question it and say, "Hey,

> this I don't understand". This is the way that I like it to operate and so, no, I wouldn't like to see it more fully explained.

Jensen's comments about the best place for supplementary questions in the materials are consistent with this view that the classroom teacher is in the best position to decide on the needs of the class.

> **Lantz**: One comment that you made last time, is that you would hate to see ALCHEM become more verbal, that is, more textual materials for the students to read through. Since you use extra worksheets, would that mean that if you were going to make some suggestions for ALCHEM revisions, it would be to put more problems in the materials which teachers could choose to use if they wanted to?
>
> **Jensen**: I wouldn't put them right in. . . . there possibly could be published for teachers that need it, an extra little book of extra questions and sheets. . . that could be available for the teacher, but I don't think they need to be in the book as it is. I really feel that there is enough in there. Because. . . you have to give the teacher something to do and you have to explain a few things, and you don't want to make the course look too overwhelming to the kids. I really think there are lots of questions. There is a lot more questions generally to do in that book the way it is designed than say in most textbooks. Especially. . . the CHEM Study. . . a lot more good questions to do. Right now I think you need a revision on the teachers answer sheets, a lot of those answers are out of date now. We need a revision on the test item booklets too. . .

Jensen places a high value on motivating students to want to learn chemisty, and considerable importance on the teacher's explaining and clarifying concepts for students. Jensen has several chemistry demonstrations that he regularly uses in his chemistry classes. These involve putting alkali metals in water, burning mixtures of potassium chlorate and sucrose, and exploding hydrogen. He offered the following rationale for using these demonstrations:

> **Lantz**: So it is a motivating thing?
>
> **Jensen**: Oh sure, sure, motivating, interesting and entertaining, if you want to know. It does all these things. I think that teachers should try. . . where it fits in, to entertain the students a little bit. . . . I think sometimes as teachers, we just forget sometimes how hard it is to sit in a desk all day. . . for five hours and a lot of the students have to do that. I think we should try to make it as interesting for them as we can without going too far.

Jensen's concern about going too far with spectacular demonstrations is related to a concern about safety. As he reflected on the use of demonstrations, he commented that he was becoming more cautious as he grew older, and no longer prepared rocket fuel, or exploded mixtures of hydrogen and chlorine.

> **Jensen**: Right, I used to do that chlorine and hydrogen one too. You know, you put it in a glass and I would shove two corks in the end, and then you'd flash flashbulb at it and those two corks would end up anywhere in the room. They'd make about three bounces back and forth across the room. The kids loved it. It was great. They'd just go, "whamo!", you know, just like a shot gun. And shoot those corks and they'd would. . . Man! I would usually aim it so one cork was aiming up at the far end of the room and the other cork was aiming down at the front. And I would put a little mark on the corks, so I would know which was which. And the one that hit the front would usually end up some where around the back of the room and the one I was aiming at the back corner would end up somewhere around the front of the room. You see, because it would it hit the back corner and bounce. But they were corks and nobody got hurt, but you know I finally started using an explosion shield. When I first started it, I never used an explosion shield. I wrapped the glass in masking tape so that if it did shatter - it never did shatter because it always blasted those corks right out. I think you know. Its very, very interesting but I was always a little bit leary of it, you know, because it really exploded. With hydrogen and chlorine in a one to one ratio. . . that will explode on. . . just light, a strong light. So there is a certain amount of danger and I have tended to - maybe its old age too. I'm a little less, 'gung ho', to do things like that. The kids sure like it. They think it's great.

The importance that Jensen attaches to entertaining students while teaching them chemistry, is also illustrated by two T-shirts bearing the decals, "Ionic Man", and "Chemists Have Solutions", which he wears to class when those topics are being introduced, and a record of Tom Leher singing the names of the elements, which he incorporates into a discussion of the periodic table. Student interest also seems to figure in selection of elective units, as the following comments indicate:

> **Jensen**: With the semester here it seems like I have time only for one optional unit, and that is usually the nuclear chemistry. I think kids find it most interesting there is so much controversy going on that point.

In his presentations to the class, Jensen feels an obligation to explain concepts until the students understand. This is reflected in his very careful discussion of problems at the blackboard, the individual assistance he provides to students, the use of additional problems for drill and practice, the tendency to omit labs so that the content can be covered thoroughly, and slowing down the pace so that the weaker students can keep up. An interesting aspect of this attitude is revealed in the following comments:

> **Jensen**: Some of them complain about the explanations of concepts. They say that it is not explained enough. I always tell the kids that that's great. That's what I like because then it gives me something to do and I can feel useful. I can explain.

It is Jensen's perspective of teaching that leads him to omit certain ALCHEM labs, and to down play the biographies of chemists and background information on chemicals, because he feels that they neither motivate students nor help them understand chemical concepts.

Jensen's view of students is reflected in his comment, "you have to like kids in order to teach them". That Jensen likes "kids" and likes teaching them is apparent from the good natured bantering that goes on between himself and the students, from the time spent with students who have trouble grasping the chemistry concepts, and from the concern for those who are "incredibly bored" and have trouble sitting still. Much of Jensen's interpretation of curriculum materials seems to be done in terms of his perception of student needs.

> **Jensen:** I like them (ALCHEM materials) much better than the textbook. In terms of the number of exercises there are to do, and I think it is convenient for the kids to work through the exercises as they take it rather then going through the whole unit and then doing a bunch of exercises at the end of the chapter. . .

A generous supply of supplementary worksheets is provided to students because, "so many of the kids need (more practice), they are always asking for extra worksheets."

Jensen allows his students to vote of whether they want their homework assignments to be marked.

> **Jensen** I say I am going to do homework assignments. Actually for the 30 class I give them a vote at the beginning of the year. I don't do this for the 10 and 20, but for the 30 I give them a vote as to whether they want me to count assignments or not as part of their mark. Or do they want me to just concentrate on tests? I do it on an in-class vote and give them a secret ballot to fill out - do you want assignments to count as part of your mark? do you want exams only to count as part of your mark? And so far I have had about 80%, "Yes, we want assignments to count. Then I give them a choice - what kind of assignments? In-class assignments? Homework assignments? Combination of both? This particular class voted for homework assignments only. I said, "Okay, the homework assignments - periodically I will call in your book just to see that you have everything done". I give them one of these extra worksheets to work on and while they are working on it I will collect their books and just leaf through it to see that they have everything done. I don't check that everything is done correctly. It would just take too long. But they have everything done - 100%. I just start deducting marks for everything that isn't done in their book. Plus I give them some of these extra worksheets as homework assignments to do I say okay take these home and do it. Then I may or may not collect it. I can't promise to collect it all but I will periodically collect one of these homework assignments from them and mark it. In terms of assignments, I usually say if I collect ten in a semester I will average the best eight and count that as one exam mark. I explain that all to them before they take their vote. I count the best eight out of ten assignments and that count is the equivalent of one exam mark.

In general Jensen treats his classes as responsible adults, speaking quietly and privately to students whose tardiness or classroom behavior is interfering with their own or the class's learning.

> **Jensen:** Some kids that have behaviour problems and are causing a disturbance in the back; I will force them to move. But if they are not causing a disturbance I'll suggest to them that they move and that hopefully it will help their mark. But if they don't want to move then I don't force them to. Some of the kids think it is a good idea if they are failing. I suggest that they should move up to the front and they say, "Hey", you know, "good idea". And I say, "Well next period you come just sit down in the front". I don't *make* them move.

He asks the students to evaluate his teaching at the end of each course, providing them with a mimeographed evaluation sheet which asks for an overall rating and invites their comments.

Jensen tries to relate his chemistry lessons to situations in the community, for example, relating the properties of hydrogen sulfide to an Alberta sour gas well which had blown wild about a year previous and was still vivid in the students' memory. Interestingly, the problem of disposing of the toxic wastes from the chemistry labs at Rutherford High has not resulted in change in practice.

> **Lantz**: Do you bring in this business of disposing of hazardous wastes. They have this collection system among all the schools. Do you tell the students much. . .

> **Jensen**: This always comes up at some time or another. It seems like usually in the Chem 30 classes this comes up, and the kids are quite concerned. Because in some of the electrochemical cells that we do, we use lead cells to copper sulphate and silver nitrate - very weak solutions. They're a little bit leary, you see. We discarded that down the sink, and the kids ask about that, and I say, "Well look, it is a very, very small amount". I say, "The amount that we are putting in the sink is infintisimal relative to the normal amounts that are dissolved by water running through the country side", you know. Yet I'm not too sure whether I believe that. I feel a little bit bad about dumping our unused chemicals, the so-called, "non-dangerous" ones, like a little bit of copper sulphate or little bit of zinc nitrate and stuff. You know, I don't think that's going to hurt the system and yet. . .

The following points summarize key aspects of Jensen's view of chemistry, teaching, students, and school setting. These perceptions seem to be related to certain beliefs and values which strongly influence Jensen's interpretation of curriculum materials for use in his classroom.

1. Chemistry is perceived as a complex body of knowledge comprising many concepts,

principles, and theories. The explanations of chemical concepts presented in high school are not and cannot be complete and students should be made aware of this. The chemicals and chemistry concepts presented in the chemistry curriculum have application in the students' everyday life. Jensen's concept of the topics that should be included in a high school chemistry program seems to be congruent with the core program outlined in the Alberta chemistry curriculum guide.

2. Explanation and motivation are seen to be essential components of effective teaching. Teachers should be considerate of students' opinions and feelings. Posting solutions to homework assignments on the tackboard and doing spectacular demonstrations are teaching techniques which have become part of Jensen's classroom routine because he values their motivational power.
3. Students are seen as having a wide range of interests and abilities. Many students need to be provided with motivation in order to learn chemistry. Some students need a great deal of help from their teachers in order to master chemical concepts.
4. The local school setting is perceived as offering excellent facilities for teaching chemistry, including lab work. The school setting includes expectations for high academic achievement.

Glenview Composite High School

Glenview Composite High School is situated between an older residential district which includes some dilapidated housing and a new residential district which includes some very expensive homes. As a result, the school's population includes a wide range of socio-economic backgrounds. The school occupies a large two storey concrete and brick building constructed in the early 1960's. As the post war "baby boom" passed through the school, the student enrollment rose to nearly 3000 in the late 1960's and then declined to about 1500 in the late 1970's. The current enrollment is about 1800, reflecting the growth of the new residential areas near the school and an active effort on the part of the current administration to build up the school's academic program. The school has ample space to accommodate its current enrollment. Figures from a local school board report show the following percentages of Glenview's 1983 graduating class (548 students) enrolled in three local post-secondary institutions: university, 14.6%; institute of technology, 15.1%; and community college, 11.9%. Compared to Rutherford, Glenview has slightly less than half as many students going on to university, about the same number going on to technical school, and slightly more going on to community college.

Glenview High School offers a wide range of courses in academic, fine arts, business, and vocational education on a semester system. The student course selection booklet for Glenview explains that the school offers both an academic enrichment program, "because some students can benefit from a faster-paced, more challenging program", and a high school prep program, "to meet the needs of a segment of our community that have been unsuccessful for some reason during the first nine years of education" The Science Department offers courses in both the enrichment program and the high school prep program as well as making provision for special projects in science. The enriched courses are offered in biology, chemistry, and physics at the grade ten level and plans are to extend the program to grade eleven next year. The high school prep science course is a general science course which is adapted to the student's interest's and abilities. The approximate enrollments in the various science courses at Glenview are shown in Table 10.

The course selection booklet for Glenview gives the following description of the chemistry courses:

> CHEMISTRY 10 - 3 Credits - Prerequisite: 50% in Grade 9 Science or 65% or better in Science 11
> This course examines the structure of atoms, how atoms are grouped in the periodic table, how they react with one another to form compounds, and how the masses of atoms and compounds are calculated. Content is supplemented by laboratory exercises and demonstrations. One or more optional units may be included.
>
> CHEMISTRY 20 - 3 Credits - Prerequisite: 50% in Chemistry 10 or 10E
> This course examines the principles of chemical bonding, the structure of various compounds, calculation of quantities of materials in chemical reactions, and an introduction to organic (carbon compound) chemistry. Content is supplemented by laboratory exercises and demonstrations. One or more optional units may be included.
>
> CHEMISTRY 30 - 5 Credits - Prerequisite: 50% in Chemistry 20 or 20E
> This course examines energy changes in chemical reactions, oxidation-reduction reactions and acid-base studies. Content is supplemented by laboratory exercises and demonstrations. Three or more optional units may be included.

The chemistry course descriptions are consistent with the topics and core-elective format of the Alberta chemistry program. However, in the course decriptions laboratory exercises are described as "supplementing" the content rather than as being part of the content. Also, the elective part of the program is termed "optional", which doesn't quite capture the intentions of the core-elective program.

The Science Department at Glenview has six full-time teachers, four male and two female, and a full-time lab aide who is female. In addition, two biology classes are taught by a female biology teacher. One of the male teachers is designated as Science Department Head. An adminstrator that I interviewed, informed me that the school's current administration was trying to, "consolidate the science department again", as it had been, "farmed out to Phys Ed, Voc Ed, and Math teachers", by a previous administration. During the period of declining enrollment some of the departments at Glenview were left with a surplus of teachers. These surplus teachers were given the option of teaching in other subject areas, rather than being transferred to another school.

Mr. Kurelek

Kurelek is in his mid-twenties and in his second year of full time teaching, after a year as a substitute teacher, mostly at the junior high school level. He holds a B. Ed. degree with a major in biological sciences. Coincidentally, he received his high school education at Glenview. He shares office space with the other science teachers in the Science Department workroom which has been set up in an unused classroom. His teaching assignment for the current school year consists of two sections each of Chemistry 10, Science 11, and one each of Science 11K (high school prep) and Biology 20. He teaches his chemistry and biology classes in one room, and his Science 11 classes another room, a scheduling arrangement which makes it possible to be near the appropriate laboratory for each clas. The classroom in which he teaches chemistry is very similar to those of Allan and Jensen; a tiered room with a demonstration desk, projection screen, blackboards, tackboards, shelves, and windows. The walls in Kurelek's room are bare except for a few science related posters on the walls (e.g., National Wildlife Week, Edmonton Space Sciences Centre)

Kurelek uses a direct expository style in teaching, making ample use of questions to check on student understanding. The ALCHEM text is the focus for most of the

Table 10

Science Course Enrollments at Glenview High School

	Grade 10	Grade 11	Grade 12
Biology	330	180	180
Chemistry	330	210	150
Physics	150	90	90
General Science	380		

teaching and student activity, with teacher presentations paralleling the discussion in ALCHEM, and student homework coming from the materials. He makes use of the "discovery" approach which is built into some to the ALCHEM materials, where students work out a number of specific cases and then are asked to make generalizations about the overall pattern. He makes extensive use of analogies in his presentations. Students are required to put their homework on the blackboard, and Kurelek marks it with colored chalk, correcting any errors that he finds. His students seem very attentive to his presentation and work diligently on homework during the classtime given for that purpose. The observation notes from Glenview High School and transcripts of the interviews with Kurelek are contained in Appendix I.

In response to the initial interview questions which focused on ALCHEM, Kurelek indicated that he found the materials very good, and particularly appreciated the compactness of the text and large number of student exercises provided. He omits some of the labs in Chemistry 10 because he doesn't feel that they serve any useful purpose. Kurelek uses ALCHEM as his basic reference, supplementing it with additional notes, particularly on the development of the atomic theory, and films from Carl Sagan's "Cosmos" series, as well as the film, "The Strange Case of the Cosmic Rays". He adapts the ALCHEM exercises on atomic structure to include neutrons in the diagrams, out of a sense of completeness. He does not do any elective units in Chemistry 10, choosing to spend the week or two left at the end of the course on review. He uses an elective unit on analytic chemistry with the Chemistry 20 classes, as do all the other Chemistry 20 teachers at Glenview.

A summary of SOS responses for Kurelek's Chemistry 10 classes is given in Table 11. In discussing the SOS summaries with him, Kurelek indicated that the students' ratings were generally consistent with his use of the materials. He expressed complete agreement with his students giving the ALCHEM periodic table the highest rating in each category of the SOS (4.4, 0.9; 4.5, 0.8; and 3.6, 1.3) because it provides a concise summary of the basic information in the course.

> **Kurelek**: . . . I definitely agree that the periodic table is probably number one.
>
> **Lantz**: Yes, it came in on top on all of the three categories with your class. What do you think it is about the table that would make them rate it so high?
>
> **Kurelek**: Well, certainly for understanding of chemistry it's such a nice summary. It's got all the information on it. Same for "exam prep". I suppose it's how you want to interpret that. I mean, you can't very well study the periodic table but it's certainly valuable during an exam. I suppose that involves preparation, too, because you have to know how to use the periodic table. As far as (being) interesting, I don't know why it would be so interesting. I suppose because it's so handy and easy to use that it makes it interesting.

He attributed the low ratings given to "mathematical problems" (3.4, 1.2) and "worked out examples of mathematical problems" (3.6, 1.1) to their position near the end of the ALCHEM 10 text which his students hadn't completed at the time of writing the SOS.

> **Kurelek**: I think pretty well most of them worked out. Like, I would agree with most of the ratings. Just maybe those math problems should be ranked higher.
>
> **Lantz**: I think we can probably explain that by the fact that they haven't actually done much with that yet.
>
> **Kurelek**: They are just starting on it now. They really get into it in Unit D. Because I think they are going to find that those math examples are going to become fairly valuable. I think everything else worked out the way I expected.

Kurelek expressed some surprise at the relatively high rating (4.0, 1.1) given to, the objectives listed at the beginning of each unit, for exam preparation, since he never mentions them in class. He speculated that since behavioral objectives are used extensively in the junior high school science materials, some students might continue the practice of using the objectives to guide their study.

Some general themes emerged from my observations and interviews with Kurelek. As with Allan and Jensen, these themes are summarized under the four categories;

Table 11

Summary of Student Opinions of the ALCHEM 10 Text

Mr. Kurelek's Chemistry 10 Classes—56 students

Rank		Mean	S.D.
	For Gaining an Understanding of Chemistry		
1.	periodic table provided in the ALCHEM 10 text:	4.4	0.9
2.	worksheets which require completion of tables:	4.3	0.9
3.	demonstrations:	4.0	0.9
4.	explanations of chemical concepts and principles:	4.0	0.9
5.	overview exercises at the end of each unit:	3.9	0.9
6.	lab work:	3.8	1.0
7.	information about sources and uses of chemicals:	3.7	1.0
8.	worksheet on the film, "Chemical Families":	3.7	1.0
9.	objectives listed at the beginning of each unit:	3.6	1.1
10.	worked out examples of mathematical problems:	3.6	1.1
11.	mathematical problems:	3.4	1.1
12.	illustrations:	3.3	1.2
13.	lab on safety and efficiency in the laboratory:	3.0	1.3
14.	biographical sketches:	2.8	1.2
	For Exam Preparation		
1.	periodic table provided in the ALCHEM 10 text:	4.5	0.8
2.	overview exercises at the end of each unit:	4.2	1.0
3.	explanations of chemical concepts and principles:	4.1	1.0
4.	worksheets which require completion of tables:	4.1	1.0
5.	objectives listed at the beginning of each unit:	4.0	1.1
6.	information about sources and uses of chemicals:	3.7	1.1
7.	demonstrations:	3.6	1.1
8.	worked out examples of mathematical problems:	3.5	1.1
9.	mathematical problems:	3.4	1.0
10.	lab work:	3.2	1.1
11.	worksheet on the film, "Chemical Families":	3.1	1.1
12.	biographical sketches:	2.8	1.3
13.	illustrations:	2.6	1.1
14.	lab on safety and efficiency in the laboratory:	1.8	1.0
	Interesting Information or Activity		
1.	periodic table provided in the ALCHEM 10 text:	3.6	1.3
2.	worksheets which require completion of tables:	3.3	0.9
3.	information about sources and uses of chemicals:	3.2	0.9
4.	demonstrations:	3.1	1.0
5.	lab work:	3.1	1.1
6.	objectives listed at the beginning of each unit:	3.0	0.9
7.	biographical sketches:	3.0	1.3
8.	explanations of chemical concepts and principles:	3.0	1.1
9.	overview exercises at the end of each unit:	2.9	1.2
10.	worksheet on the film, "Chemical Families":	2.9	1.1
11.	illustrations:	2.9	1.1
12.	worked out examples of mathematical problems:	2.6	1.0
13.	mathematical problems:	2.5	0.9
14.	lab on safety and efficiency in the laboratory:	2.4	1.0

chemistry, teaching, students, and school setting. Kurelek's interpretation of curriculum materials for use in his classroom does not seem to be characterized by such strongly held views as those of Allan or Jensen. He seems to accept the organization and level of treatment of the topics in the ALCHEM text without much criticism. He also goes along with the selection of the elective unit for the Chem 20's made by the other teachers as well as with the use of a common final exam which is prepared by other teachers. These observations may reflect his willingness to defer to more experienced teachers. His comment that he had consulted a great deal with the other chemistry teachers last year, his first year of teaching, supports that view.

Although his views do not seem to be strongly held, Kurelek does have some definite views on the teaching of chemistry, as the following discussion indicates. Kurelek regards chemistry as a body of knowledge which is growing and expanding and which serves to illustrate the nature of science. Kurelek expands on the history of the development of the atomic theory and uses the film, "Strange Case of the Cosmic Rays", so that students will get a sense of how a theory develops, a concept which he feels is quite important.

> **Kurelek**: Because I think in every science course you. . . . have the obligation to. . . go into the scientific method a little bit, because if they get anything out of the course. . . they're probably not going to remember too many things they had to memorize. But at least if they get an appreciation of how science works, then when some scientist stands up and talks about something, well at least they will be able to realize how a theory came about. . . Also I think it doesn't hurt to give people credit for what they do. . . Everybody knows who Wayne Gretzky is but not many people know who Rutherford is, and if I just said, "This is Rutherford's model", probably they wouldn't remember it. But if you can show what experiment he did, maybe they'll get a little. Maybe that might make them remember his name a little more.
>
> **Lantz**: . . . it is interesting how a personal anecdote about someone catches people's attention. And so they fix that in their minds more than, for instance, a theory or an equation or something to that effect.
>
> **Kurelek**: And like I told them, everybody knows Gretzky's name, but who has more affect on their life? Somebody like Gretzky, whether he scores a hundred goals or not, or somebody like Rutherford? They may not realize it but he probably had a lot more affect on their lives than certainly Gretzky did.
>
> **Lantz**: I quite agree with what you're saying there. Do you feel that the university formed your attitudes to teaching science, or is that something that's more or less your own?

> **Kurelek**: Yes and no. It's kinda funny. It's sorta something that sticks in my mind as a student in a genetics class at university. One of our students said, "Why are you talking about history? Why don't you just tell us, 'this is the way it is', and that's it"? His answer was, "Well here in university it's one thing you should never do is totally accept something as being true". He said, "In my life I have seen so may things in science that people accepted were true and later on they were shown to be untrue. So if I just teach you something as being true without showing you how we arrived at this conclusion and arguments against it. . . You know you're never going to question whether that's true or not. You're just going to accept it as true. But if you're shown how this idea was arrived at maybe you can disagree with it then".

Kurelek also uses films to spark student interest in the development of science.

> **Kurelek**: The "Cosmic Ray" one does, yes. I think that sparks a little bit of interest in them. Because I remember, when I went to school, seeing that film and I found it really highly interesting. Like I assumed that particles like protons and electrons and neutrons and that. . . You read in the paper all the time about scientists discovering a new particle. . . and it doesn't really hit home as to what they are talking about 'til you see something like that film. . . The universe is just not quite as simple as it first appears. . .

> **Lantz**: . . . With the Sagan film I think there is a real sense of wonder at the size of the universe. That's something that ought to be part of science teaching and often it gets so routine for the teacher to forget about that. All the awesomness of nature doesn't come through when you're teaching. It's neat when there is a film that does that.

> **Kurelek**: I think with Carl Sagan too they get. . . I don't think they often get exposed to somebody who just seems so totally enthusiastic about what they're doing. In fact when the film first starts you get a couple of guys looking around, "Is this guy for real?", you know. Because he just seems so *into* what he does. I'm sure he is. They can't believe that. . .

Kurelek selects teaching procedures and activities on the basis of his perception of their effectiveness. Notes are given on the blackboard so that students will think about the material as they take it down. He omits labs which bore the students (use of the laboratory balance) or develop a concept that the students already understand (using molecular models to illustrate conservation of mass in chemical reactions). In the classes that I observed, Kurelek made effective use of analogies in his presentation, comparing atoms to people, protons to bullets, and binding energy to glue. I asked him if he used analogies extensively in his teaching:

> **Kurelek:** I found. . . I think this is what you. . . were saying about anecdotes. . . They sort of make you remember it. . . If you give an example about some things even though it makes you seem a bit crazy or something, I think it helps them remember it to fix it in their mind. I like to use that as much as possible.

Kurelek seems to have a good relationship with his students, being friendly but firm is his manner. He credits the students with having learned some basic chemistry in junior high school. These views lead him to omit some of the ALCHEM exercises because he feels they wouldn't serve any useful purpose. He comments that you can work with classes of 30 to 35 with good academic students but not if you have a "bunch of turkeys".

There was very little in the observations and interviews which gave any sense of what Kurelek's views of his school setting were. He doesn't spend any time on discussing careers in science, but he did express an interest in getting a book which addressed that topic.

Perhaps because of his limited experience, Kurelek did not have as much to say about his own classroom practice as did Allan and Jensen. There are, however, some identifiable values and beliefs which shape Kurelek's perceptions of chemistry, teaching, and students. These values and beliefs seem to guide the translation of curriculum materials into practice in his classroom.

1. Chemistry is perceived as a body of knowledge which is steadily growing and expanding. High school chemistry should include an examination of the way that scientific theories develop and change (i.e., the nature of science). The core outline given in the Alberta chemistry curriculum guide is an adequate high school chemistry program.
2. Selection of effective teaching procedures and activities is seen as an important component of teaching. A straightforward expository approach with abundant use of questioning is an effective means of teaching chemistry. Analogies are an effective way of helping students learn and remember chemical concepts.
3. Students have a wide range of abilities and interests, which must be considered when selecting appropriate teaching strategies. Students should not be required to go through activities if they already understand the concept that the activity was designed to teach.

A Comparison of Three Selected Chemistry Teachers

In some respects the three chemistry teachers who were observed and interviewed held shared perceptions of chemistry, teaching, students, and school setting. In other respects many of their perceptions were quite different. A comparison of the three teachers' views of the four curriculum commonplaces follows.

Allan sees chemistry as a well established body of concepts, principles, and theories. In his view, there is a definite set of topics from the body of chemical knowledge which ought to be included in a high school chemistry program, including several topics which are not included in the current core chemistry program in Alberta. These theoretical topics were all part of chemistry courses that Allan had taught previously, and are included in his chemistry classes in preference to the electives on applied chemistry which are encouraged in the chemistry curriculum guide. With his students being taught a combination of the previous three Alberta chemistry programs, it is little wonder that Allan has trouble finishing the course in the time allotted. Allan includes numerous examples from the local natural gas industry in his chemistry classes, indicating that he does place some value on teaching his students about the interactions of science, society, and technology (STS). It seems that the value that Allan places on teaching his classes about the STS connection was formed in part by his involvement with a local group aimed at protecting agricultural land from industrial contamination, and from his conversations with instructors at a nearby Junior College.

Jensen shares with Allan the perception of chemistry as a complex body of concepts principles and theories. In Jensen's case, however, the topics deemed appropriate for high school chemistry are congruent with those included in the ALCHEM program. It seems noteworthy that although Jensen used the CHEM Study text for several years before ALCHEM was written, he has not carried over any of the CHEM Study topics into his current teaching in the way that Allan has. Perhaps Jensen has adopted ALCHEM more completely than Allan because he was involved in piloting early versions of ALCHEM and in providing feedback to the author group through the meetings of the local chemistry teachers group, while Allan was not involved. This interpretation would be consistent with Fullan's (1982) contention that personal contact is the primary determinant of teacher acceptance of curriculum innovations.

Kurelek perceives chemistry as an established body of knowledge which is steadily growing and expanding, and as such, can be used to illustrate some aspects of the nature of science. In particular, the study of atomic structure provides an opportunity to teach students something about the way that scientific theories develop and change. Kurelek attributes this view of science, including chemistry, to a genetics professor that he had at university. The value that Kurelek places on teaching this aspect of science is consistent with Aikenhead's (1983) observation that teachers' experience in science courses at university seems to be a major factor in determining what teachers feel students should get out of high school science courses. The view of chemistry as a steadily developing body of knowledge does not seem to be part of the functional paradigms of Allan and Jensen, possibly because their university experience in science was different from Kurelek's. In terms of the topics covered, Kurelek limits his presentation to the core topics covered in the ALCHEM materials, and goes along with the choice of elective units made by other chemistry teachers in the school. His acceptance of the materials as they are may be a function of his lack of teaching experience and/or his limited training in chemistry. It is interesting to note that unlike Allan and Jensen, Kurelek does not have difficulty completing the Chemistry 10 and 20 courses in the allotted time. Perhaps he has not been teaching long enough to accumulate additional material to include in his classes. Of the three teachers, Allan is least restrained in selecting and sequencing topics for his chemistry classes, and in selecting course material. Perhaps this is due to his being the only Chemistry 30 teacher in his school. Brauer (1981) found that in schools with more than one Chemistry 20 teacher there was a "consensus" effect which tended to centralize curriculum decision making. Brauer's finding seems consistent with the situations Parkland, Rutherford, and Glenview high schools.

Allan believes that academic rigor and pedagogical efficiency are essential components of effective teaching. By using multiple references, rather than ALCHEM alone, he is able to give a more thorough presentation of each of the topics covered in his chemistry classes. By using dimensional analysis, rather than formula substitution, he is better able to develop student's problem solving skills. Allan values efficient teaching techniques which allow him to make the best use of the time available for teaching chemistry. In some situations, such as evaluating student lab reports, pedagogical efficiency is chosen over academic rigor. In other situations, such as teaching stoichiometry, academic rigor is valued more than pedagogical efficiency. Allan does not consider the ALCHEM materials to be a textbook because they don't give enough detailed information on chemical theory; although he does appreciate the pedagogical efficiency inherent in the "worktext" format.

For Jensen, providing students with lucid explanations and motivating them to learn chemistry, are necessary aspects of effective teaching. Although Jensen shares with Allan the belief that clear, thorough explanations of concepts and principles are essential aspects of chemistry teaching, he seems to feel much more responsible for motivating his students to want to learn chemistry than Allan does. Perhaps this difference in perception is due to differing school and community expectations. At Parkland High School, chemistry is considered a difficult academic course intended for university-bound students and a high attrition rate seems to be accepted. Given the high attrition rate in chemistry classes at Parkland, the students that Allan gets in his Chemistry 30 classes are likely only the most capable and conscientious. At Rutherford, most parents expect that their children will be successful in a matriculation program, an expectation that puts considerable pressure on teachers to see that their students are successful in academic courses. While Allan is pressed for time because of the extra topics he covers, Jensen is pressed for time because of the extra time he spends getting his students to master the core topics.

Kurelek beleves that student understanding of chemistry can be accomplished by a direct expository teaching technique which makes extensive use of analogies to help students grasp and remember abstract concepts. Kurelek shares with Jensen and Allan the belief that student "understanding" is the main purpose of teaching. With all three teachers, student understanding seems to mean that the students are able to answer homework or examination questions without assistance. The high value placed on student understanding is consistent with the observation of MacDonald and Leithwood (1982), that a major factor in curriculum decision making is teachers' overriding need for "achievement", defined in terms of assisting the students to become more cognitively competent.

Allan believes that students are capable of handling demanding academic work and that they will benefit from the experience. Jensen also expects his students to do their assignments, but he seems much more inclined to provide assistance to his students than Allan does. Jensen believes that it is part of his job as a teacher to motivate students who are not interested in chemistry and to provide as much help as necessary to help students become more "cognitively competent" in chemistry. Allan, on the other hand, seems to regard motivation as the students' responsibility, and seems to hold the view that students who are experiencing great difficulty in learning chemistry ought not to be taking it. Kurelek believes that the wide range of abilities and interests of the students in his classes need to be considered when selecting teaching strategies. More than Allan or Jensen, Kurelek credits Chemistry 10 students with having learned some basic chemistry in junior high school. This is likely because he has experience teaching junior high school which Allan and Jensen do not have. He believes that students have come into high school with some knowledge of chemisty and should not be required to do exercises designed to teach them concepts they already know. For this reason, he omits some parts of the ALCHEM materials, which is likely another reason that he has no difficulty in completing the Chemistry 10 and 20 courses.

Although Parkland High School has all the necessary materials and equipment for doing high school chemistry labs, Allan perceives his school setting as inhibiting student experimental work, because of the lack of a laboratory assistant. In this regard, both Jensen and Kurelek, believe that their schools have excellent facilities. All three teachers regard their school systems as being able to provide all the additional reference material and audiovisual resources that they need. In terms of the larger school setting, Allan seems to place the highest value on applying chemistry to situations in the local community, by making frequent references to the local gas industry, and by specifically addressing the need for a scientifically literate society. In his teaching Jensen places somewhat less emphasis than Allan on the STS connection and Kurelek doesn't mention it at all.

Several techniques, exemplars, and routines, consistent with the teacher's beliefs and values concerning the curriculum commonplaces, also seem to be part of the functional paradigms of the three selected chemistry teachers. The interview data indicate that a particular set of routines have become part of the classroom practice of each of the three teachers because the routines are valued for their pedagogical power. These routines seem to play an important role in determining how curriculum materials are translated into classroom practice.

The technique of working through illustrative examples (exemplars) while questioning students about the procedure, followed by having students do similar questions on their own, is used by all three teachers. This technique seems to be valued as an effective way of getting students to understand the concepts involved. Having students write out solutions to assigned homework is a routine used by Allan and Kurelek, but not by Jensen. It seems to be valued as an effective way of providing feedback to both the teacher and the students on how well students are understanding the concepts being taught. This technique also provides some motivation to students to complete their homework in case they are called on write it out on the blackboard. Jensen posts worked out solutions to assigned problems on the tackboard at the back of the room so that students can check their own work. Jensen provides motivation to his students to do assignments by periodically calling in students' note books for an evaluation that is based on the number of completed assignments. All three of teachers have what Allan calls, "a bag of tricks," a repertoire of demonstrations, illustrations, and examples which they have found to be particularly effective in getting students to understand chemical concepts.

The observations and interviews conducted as part of the current study provide some information on the beliefs, values, techniques, exemplars, and routines of the three selected chemistry teachers. In other words, for three teachers we have identified some of the elements in the functional paradigms which guide interpretation of curriculum materials. As the foregoing summary indicates, some of these elements are shared by all three teachers and some are unique to individuals. In the next section the results of the CCPS will be summarized, discussed, and analyzed with the view of gathering more information about the nature of teachers' functional paradigms and the extent to which they are shared among teachers.

B. The Chemistry Classroom Practice Survey

In the following section the results of the Chemistry Classroom Practice Survey (CCPS) are reported and discussed. As reported in Chapter 3, the CCPS was sent to 50 schools. Completed CCPS questionnaires were returned from 37 schools, for a school return rate of 74%. A total of 69 teachers responded to the CCPS for an estimated teacher response rate of 61%.

Background Information

In this section basic demographic data about the teachers in the sample, and the schools and communities in which they work, are summarized and discussed. The method of calculating sampling error for the proportions of responses in each category of the CCPS was outlined in Chapter 3. The calculations revealed that if 50% of the respondents to a particular item on the CCPS select a certain category, the 95% confidence interval for that proportion is 37.8% — 62.2%. For a proportion of 25% the 95% confidence interval is 14.5 — 35.5, and for a proportion of 10% it is 2.7 — 17.3.

Of the 69 teachers who returned the CCPS questionnaire, 56 were male, 12 were female, and one person did not respond to the item on the questionnaire concerning gender. Of the 68 teachers who did indicate their sex, 82.4% were male and 17.6% were female. The preponderance of males in the sample is consistent with the findings of Orpwood and Alam (1984), whose randomly selected sample of Alberta senior high school science teachers was 85.7% male.

Table 12 summarizes information about the communities and schools of the chemistry teachers who responded to the CCPS. The data are presented separately for males and females as well as for the total sample. Since one teacher did not respond to the CCPS questions about community and school the data are based on the responses of 67 teachers. The figures in Table 12 indicate that approximately one half of (50.7%) the teachers in the sample work in communities which have populations of less than 30 000, while the other half (49.2%) work in communities with populations of 30 000 or greater. In other words, the sample represents a nearly even rural / urban split. Urban communities provide the school setting for 43.6% of the male teachers in the sample, and 75.0% of the females. As indicated in Chapter 3, the school return rate for the CCPS questionnaire was

Table 12

Description of Community and School

	Percent of Males	Percent of Females	Percent of Respondents
Population of Community			
less than 1000	25.5	0.0	20.9
1 000 - 4999	18.2	25.0	19.4
5 000 - 29 999	12.7	0.0	10.4
30 000 - 99 999	10.9	16.7	11.9
100 000 or more	32.7	58.3	37.3
(N)	55	12	67
Grades in School			
K or 1 - 12	27.3	8.3	23.9
7 - 12	9.1	0.0	7.5
8 - 12	1.8	0.0	1.5
9 - 12	1.8	16.7	4.4
10 - 12	60.0	75.0	62.7
(N)	55	12	67
Number of Teachers on Staff			
1 - 19	30.9	25.0	29.9
20 - 39	29.1	0.0	23.9
40 - 59	10.9	25.0	13.4
60 - 79	12.7	25.0	14.9
80 or more	16.4	25.0	17.9
(N)	55	12	67
Number of Chemistry Teachers on Staff			
1 - 2	50.9	33.3	47.8
3 - 4	29.1	41.7	31.3
5 - 6	20.0	25.0	20.9
(N)	55	12	67

lower from rural jurisdictions than from urban jurisdictions, thus rural teachers are likely somewhat under represented in the survey sample.

The majority (62.7%) of the teachers in the sample work in schools which include only the three senior high school grades (10, 11, and 12). An additional 13.4% work in schools which include one or more junior high school grades (7, 8, and 9), and the remaining 23.9% work in schools which include all twelve grades. Schools which have only senior high grades employ 60.0% of the males in the sample and 75.0% of the females, while schools with all twelve grades employ 27.3% of the males but only 8.3% of the females.

Slightly more than half (53.8%) of the respondents work in schools which have less than 40 teachers on staff, and the remainder (46.2%) work in schools with 40 or more teachers on staff. The larger schools employ 40.0% of the males and 75.0% of the females in the sample. Slightly over half (52.2%) of the respondents teach in schools which have three or more chemistry teachers on staff, with the remainder working in schools with only one or two chemistry teachers. The schools with the larger science departments employ about half (49.1%) of the males in the sample and two-thirds (66.7%) of the females. The female teachers in the study sample are concentrated in the large urban senior high schools.

Table 13 summarizes teacher ratings of the facilities in their school for teaching chemistry, and their description of their students' attitude toward learning chemistry. The responses are tabulated separately for teachers in rural and urban schools, as well as for the total sample. Over half (54.4%) of the respondents rated the facilities in their schools as better than satisfactory for teaching chemistry, while 17.6% rated them as less than satisfactory. Generally urban teachers rated their schools' chemistry facilities higher than did their rural colleagues, with 27.3% of urban teachers giving a rating of "excellent", compared to only 5.7% of the rural teachers. These findings are consistent with the interview data presented earlier where the two urban teachers felt that the facilities in their schools were excellent for teaching chemistry, while the rural teacher felt that the lack of lab assistance prevented him from doing more experimental work with his students. The CCPS data suggest that a school's facilities are perceived as more of an impediment to teaching chemistry than is student attitude.

Table 13

Teacher Ratings of School Facilities and Description of Student Attitude

	Percent of Rural Teachers	Percent of Urban Teachers	Percent of Total Respondents
School Chemistry Facilities			
Excellent	5.7	27.3	16.2
Good	40.0	36.4	38.2
Satisfactory	28.6	27.3	27.9
Unsatisfactory	20.0	9.1	14.7
Very Unsatisfactory	5.7	0.0	2.9
(N)	(35)	(33)	(68)
Student Attitude Toward Chemistry			
Excellent	2.9	3.0	2.9
Good	57.1	69.7	63.2
Satisfactory	37.1	27.3	32.4
Unsatisfactory	2.9	0.0	1.5
Very Unsatisfactory	0.0	0.0	0.0
(N)	(35)	(33)	(68)

Nearly two-thirds (66.1%) of the respondents described their students' attitude toward learning chemistry good or excellent. A slightly larger proportion of the urban teachers (72.7%) described their students' attitude towards learning chemistry as better than satisfactory than did the rural teachers (60.0%). Only one teacher described his students' attitude as "unsatisfactory", and that teacher was in a rural school.

Table 14 summarizes information about the teaching assignment of the teachers in the sample. The teaching assignment is examined from the point of view of the number of different courses taught and the number of students taught. The percentage of chemistry in the teaching assignment is reported as well. The data are presented separately for teachers in rural and urban schools as well as for the total sample. Over half (51.4%) of the teachers in the sample teach four or five different courses at one time, with 60.0% of the rural teachers and 42.5% of the urban teachers carrying this load. The modal number of courses taught is five for rural teachers, compared to three for urban teachers. While 11.4% of the rural teachers reported teaching only one course, none of the urban teachers did. It seems likely that respondents who reported teaching only one course were administrators in rural schools who were teaching part time.

Teaching over 100 students at one time is reported as the work load of 63.3% of the teachers in the sample, with 34.2% of the rural teachers and 93.9% of the urban teachers carrying this work load. The modal number of students taught is between 50 and 99 for the rural teachers, compared to between 100 and 150 for the urban teachers. Chi-square analysis of a crosstabulation of the number of students taught by rural and urban teachers indicated that, on the average, urban teachers teach significantly more students than their rural counterparts (chi-square=23.5, df=1, $p<0.0001$).

Over half of the urban teachers (54.5%) have over 80% chemistry in their teaching assignment, compared to 14.7% of the rural teachers. None of the urban teachers reported less than 20% chemistry in their teaching assignment, while 26.5% of the rural teachers did. The respondents were divided into two groups, teachers with less than 60% chemistry in their teaching assignment, and those with 60% or more. Chi-square analysis of a crosstablulation of these two groups by rural and urban teachers indicated that significantly more urban than rural teachers have 60% or more chemistry in their teaching assignments (chi-square=30.4, df=1, $p<0.0001$).

Table 14

Teaching Assignment

		Percent of Rural Teachers	Percent of Urban Teachers	Percent of Total Respondents
Number of Different Courses Taught				
one		11.4	0.0	5.9
two		11.4	12.1	11.8
three		17.1	45.5	30.9
four		11.4	36.4	23.5
five		48.6	6.1	27.9
	(N)	(35)	(33)	(68)
Number of Students Taught				
less than 50		22.9	0.0	11.8
50 - 99		42.9	6.1	25.0
100 - 149		25.7	48.5	36.8
150 - 199		0.0	33.3	16.2
200 or more		8.5	12.1	10.3
	(N)	(35)	(33)	(68)
Percent Chemistry in Teaching Assignment				
less than 20%		26.5	0.0	13.4
20% - 39%		41.2	3.0	22.4
40% - 59%		14.7	9.1	11.9
60% - 79%		2.9	33.3	17.9
80% - 100%		14.7	54.5	34.3
	(N)	(34)	(33)	(67)

Clearly, there is a difference in the teaching assignment of rural and urban teachers; while rural teachers generally teach more courses, urban teachers teach more students. Specialization in chemistry occurs more frequently in urban than in rural schools. The lower percentage of chemistry in the work load of rural teachers is a consequence of the larger variety of courses they are required to teach. That nearly half (45.4%) of the urban teachers have teaching assignments that involve working with more than 150 students at one time, is a consequence of Chemistry 10 and 20 being three credit courses. This means that a chemistry teacher can meet as many as seven different chemistry classes during one semester.

The figures in Table 15 indicate that more than two thirds (67.6%) of the chemistry teachers in the sample are over age 35. Fully one half (51.5%) of the teachers are within one age decade, between 36 and 45. The females in the sample are somewhat younger than the males, with 50.0% under age 36, compared to only 28.6% for the males. The average age of the teachers was estimated by multiplying the number in each age interval times the midpoint of the interval, summing to get the total age, and then dividing the total age by the number of teachers. The average age was estimated to be 39 for the males, 35 for the females, and 39 overall. Using the same method, Opwood and Alam (1984) estimated the average age of Alberta senior high school science teachers to be 37. The years of teaching experience indicate that while 72.0% have been teaching for ten years or more, only 52.9% have been teaching chemistry for that long. These figures suggest that some teachers have moved into chemistry teaching fairly recently, possibly as the result of the reassignment of subject areas which has accompanied declining enrollments in many schools such as Parkland and Glenview.

As the numbers in Table 16 show, slightly more than half (53.7%) of the teacher sample reported a specialization in physical science. Two-thirds (66.7%) of the females in the sample report a physical science major compared to about half (50.9%) of the males. With respect to the number of chemistry courses completed, 75.0% of the females reported completing more than three chemistry courses, compared to 59.2% of the males, for an overall proportion of 62.2%. Overall, the female teachers in the sample have more training in chemistry than do the males. Analysis of a crosstabulation of area of specialization (physical science / non physical science) for rural and urban teachers

Table 15

Teacher Age and Experience

	Percent of Males	Percent of Females	Percent of Respondents
Age			
under 26	0.0	8.3	1.5
26 - 35	28.6	41.7	30.9
36 - 45	51.8	50.0	51.5
46 - 55	16.1	0.0	13.2
over 55	3.6	0.0	2.9
(N)	56	12	68
Years of Teaching Experience			
1	1.8	8.3	2.9
2 - 5	7.1	33.3	11.8
6 - 9	12.5	16.7	13.2
10 - 13	25.0	16.7	23.5
14 or more	53.6	25.0	48.5
(N)	56	12	68
Years of Experience Teaching Chemistry			
1	3.6	8.3	4.4
2 - 5	19.6	41.7	23.5
6 - 9	21.4	8.3	19.1
10 - 13	17.9	25.0	19.1
14 or more	37.5	16.7	33.8
(N)	56	12	68

Table 16

Teacher Training

	Percent of Males	Percent of Females	Percent of Respondents
Area of Specialization			
Physical Science	50.9	66.7	53.7
General Science	14.5	0.0	11.9
Biological Science	23.6	25.0	23.9
Mathematics	9.1	8.3	9.0
Administration	1.8	0.0	1.5
(N)	(55)	(12)	(67)
Chemistry Courses Completed			
1 or less	7.4	16.7	9.1
1.5 - 3	33.3	8.3	28.8
3.5 - 5	40.7	33.3	39.4
5.5 - 7	3.7	16.7	6.1
7.5 or more	14.8	25.0	16.7
(N)	(54)	(12)	(66)
Science Education Courses Completed			
1 or less	21.8	25.0	22.4
1.5 - 2	23.6	16.7	22.4
2.5 - 3	12.7	33.3	16.4
3.5 - 4	9.1	16.7	10.4
4.5 or more	32.7	8.3	28.4
(N)	(55)	(12)	(67)

indicated that significantly more urban than rural teachers had a specialization in the physical sciences (chi-square=18.3, df=1, p<0.0001). Analysis of a crosstabulation of the number of chemistry courses taken by rural and urban teachers revealed that a larger proportion of urban than rural teachers are chemistry majors (chi-square=15.1, df=1, p<0.0001). Generally, urban chemistry teachers are more specialized in chemistry than their rural counterparts, both in training and in teaching assignment. As a consequence, the teachers with the most training in chemistry are teaching the largest number of chemistry students.

Teachers' reponses to the CCPS item concerning number of science education courses completed, suggests a lack of shared meaning for the term, "science education course". One respondent circled the term and wrote; "I assume you mean other science courses besides chemistry". The term was intended to mean curriculum and instruction or "methods" courses for science majors offered by faculties of Education. More than three curriculum and instruction course in science would suggest graduate level work in science education, and it seems unlikely that such would be the case for nearly 40% of the sample. Apparently some of the teachers counted other science courses (e.g., biology and physics) as science education courses. Consequently, the meaning of these responses is unclear and they will not be used in any subsequent categorization or analysis.

Table 17 summarizes teachers' rating of the adequacy of their own background for teaching different aspects of high school chemistry. The data are tabulated separately for chemistry majors (defined here as teachers who have completed more than three university chemistry courses), and for non-majors (defined as teachers who have completed three or less university chemistry courses), as well as for the total sample. Of the 67 teachers whose responses are tabulated in Table 17, 41 (61.2%) are designated as chemistry majors and 26 (38.8%) as non-majors. Over three-quarters (76.1%) of the respondents rated the adequacy of their background for teaching high school chemistry as good or excellent. A higher proportion of chem majors (92.7%) than non-majors (50.0%) rated their background for teaching high school chemistry as better than satisfactory. Analysis of this distribution of responses, yielded a chi-square of 13.7 with one degree of freedom (p=0.0002).

Table 17

Teacher Ratings of Own Background

	Percent of Non-Majors	Percent of Chem Majors	Percent of Respondents
Adequacy of Background for Teaching High School Chemistry			
Excellent	11.5	51.2	35.8
Good	38.5	41.5	40.3
Satisfactory	38.5	7.3	19.4
Unsatisfactory	11.5	0.0	4.5
Very Unsatisfactory	0.0	0.0	0.0
(N)	26	41	67
Adequacy of Background for Teaching Chemistry Lab Work			
Excellent	0.0	41.5	25.4
Good	19.2	46.3	35.8
Satisfactory	65.4	12.2	32.8
Unsatisfactory	7.7	0.0	3.0
Very Unsatisfactory	7.7	0.0	3.0
(N)	26	41	67
Adequacy of Background for Teaching Science and Society			
Excellent	15.4	2.4	7.5
Good	26.9	63.4	49.3
Satisfactory	34.6	24.4	28.4
Unsatisfactory	15.4	9.8	11.9
Very Unsatisfactory	7.7	0.0	3.0
(N)	26	41	67
Adequacy of Background for Teaching Nature of Science			
Excellent	11.5	5.0	7.6
Good	30.8	57.5	47.0
Satisfactory	42.3	25.0	31.8
Unsatisfactory	15.4	12.5	13.6
Very Unsatisfactory	0.0	0.0	0.0
(N)	26	40	66

Only 61.2% of the respondents rated their background for teaching chemistry laboratory work as better than satisfactory. The proportion of chemistry majors who gave this rating was 87.8% compared to only 19.2% for the non-majors (chi-square = 28.7, df=1, $p<0.0001$). None of the chemistry majors rated their background in this regard as less than satisfactory, while 15.4% of the non-majors rated their background as unsatisfactory or very unsatisfactory.

Item 13 on the CCPS asked teachers, "How do you rate the adequacy of your background for teaching the social implications of science? (e.g., acid rain, nuclear energy)". Of the teachers responding to this item, 56.8% rated their background as good or excellent, with 65.8% of the chem majors and 42.3% of the non-majors giving that rating. None of the chem majors rated their background as less than satisfactory, while 15.4% of the non-majors did.

Item 14 on the CCPS asked teachers, "How would you rate the adequacy of your background for teaching the nature of science? (i.e., process and philosophy of science)". In this regard, 54.6% of the respondents rated their background as more than satisfactory, and 13.6% as less than satisfactory. Of the chemistry majors, 62.5% rated their background as more than satisfactory, and 12.5 as less than satisfactory in this regard, compared to 42.3% and 15.4%, respectively, for the non-majors.

In all of the questions concerning adequacy of background, a higher proportion of chemistry majors than non-majors rated their background as good or excellent. The discrepancy between the ratings of these two groups is greatest when it comes to chemistry laboratory work. Perhaps the sense of inadequacy in chemistry laboratory work indicated by the nonmajors is related to the "sinister side" of chemistry that the chemistry curriculum guide alludes to with references to, "the possiblity of accidents and the potential hostility of the chemical laboratory" (Alberta Education, 1977, p. 11). It may be that one of the significant factors in how chemistry teachers interpret curriculum materials in their classrooms is related to their perception of the adequacy of their background for teaching different aspects of chemistry.

As one would expect, the perception of adequacy seems to be related to number of chemistry courses completed. What is unexpected is that fully half (50.0%) of the non-majors regard the adequacy of their training as good or excellent. Similarly, 42.3% of the non-majors rated their background as good or excellent for teaching both the social implications of science and the nature of science. This could mean that the teachers place very little emphasis on this aspect of chemistry teaching and regard their background as more than adequate for their purposes, or it could mean that they have acquired background from other courses or from personal reading. Since most of the teachers in the survey sample have been teaching chemistry for over a decade, they may have become so familiar with the high school program that they feel they have an adequate background in spite of the small amount of formal training they have in chemistry. In other words, experience in teaching high school chemistry may be perceived to compensate for lack of university training in the subject.

Objectives of the Alberta Chemistry Program

Section 2 of the CCPS listed each of the seventeen objectives stated for the Alberta high school chemistry program in the document, *Curriculum Guide for Senior School Chemistry*, (Alberta Education, 1977). Key portions of this document, including the stated objectives, are contained in Appendix A. A five-point Likert rating scale was provided after each objective and teachers were asked to circle the number which represented the emphasis they placed on that objective in their own chemistry teaching. The low end of the rating scale was designated by "1" (no emphasis), and the high end by "5" (heavy emphasis). The objectives are listed in Table 18, in order of their mean teacher ratings. The standard deviations of the teacher ratings for each objective are given in Table 18 as well. Since standard deviation is a measure of the spread of individual scores, the standard deviation of the ratings for a particular objective can be taken as a measure of the consistency of the the teachers' indications of the emphasis placed on that objective (Erickson & Nosanchuck, 1977). The smaller the standard deviation the more consistent the ratings. On a five-point scale the maximum standard deviation is 2.00. The method of calculating the sampling error in the mean ratings is outlined in Chapter 3. With a sample size of 65 and a standard deviation of 1.00 the standard error is estimated to be 0.12. In general, the probability is 95% that means will be within the range of ±0.24 about the sample means. There will be slight variations depending on the actual number of responses an the standard deviation on individual items. In the following discussion the

Table 18

Mean Teacher Ratings of Alberta Chem Program Objectives

Rank	Objective Number and Statement	Mean	S.D.
1.	(2.1) Acquire a working knowledge of the fundamental ideas in chemistry.	4.52	0.58
2.	(2.2) Acquire a working knowledge of the application of the fundamental ideas of chemistry.	4.09	0.68
3.	(1.3) Develop skill in the methods used by chemists such as skills in individual and group problem solving.	3.59	0.79
4.	(2.3) Acquire a working knowledge of the interrelationships among the different sciences and mathematics	3.46	0.83
5.	(2.4) Acquire a working knowledge of the tentativeness of chemical theory	3.44	0.85
6.	(1.1) Develop skill in the methods used by chemists such as processes in scientific inquiry: observing, hypothesizing, classifying, experimenting, and interpreting data.	3.42	0.81
7.	(7.0) Develop a background of chemical knowledge and skills prerequisite to future careers.	3.40	1.03
8.	(1.2) Develop skill in the methods used by chemists such as skills in the cognitive, affective, and psychomotor domains.	3.27	0.80
9.	(4.1) Acquire a background of knowledge and experiences in the application of chemistry such as chemistry in the home	3.15	0.98
10.	(3.3) Acquire a background knowledge about such issues as use and misuse of chemicals such as preservatives, additives, insecticides.	3.00	1.01
11.	(3.2) Acquire a background knowledge about such issues as chemistry of environmental pollution.	2.99	0.95
12.	(3.1) Acquire a background knowledge about such issues as use and depletion of natural resources.	2.96	1.02
13.	(4.4) Acquire a background of knowledge and experiences in the application of chemistry such as chemistry in industry.	2.91	0.88
14.	(5.0) Develop an awareness and critical understanding for decision-making on value issues arising out of the use and misuse of chemistry.	2.71	0.92
15.	(6.0) Acquire a knowledge and an appreciation of the history and philosophy of chemistry.	2.71	0.88
16.	(4.3) Acquire a background of knowledge and experiences in the application of chemistry such as consumer chemistry.	2.68	0.94
17.	(4.2) Acquire a background of knowledge and experiences in the application of chemistry such as leisure-time activities such as photography, automotives.etc.	2.37	0.86

numbers given in parentheses are the mean and standard deviation for that particular item.

The two objectives that teachers indicated that they emphasize the most, refer to the "fundamental ideas in chemistry" (4.52, 0.58) and "application of the fundamental ideas in chemistry" (4.09, 0.68). The emphasis indicated by these rankings is consistent with the classroom practice of Allan, Jensen, and Kurelek, where laying down a solid foundation of chemical principles and their application to problem solving is the chief preoccupation. This emphasis is also consistent with Brauer's (1981) finding that Chemistry 20 teachers emphasized the discipline oriented cognitive concepts in both the core and elective parts of the program. In addition, Orpwood and Alam (1984) found that, "understanding of scientific facts, concepts and laws", was the highest ranked objective among the Canadian senior high school science teachers that they surveyed, and that "understanding the practical applications of science" was ranked fourth of fourteen objectives rated. Apparently, a valuing of the fundamental ideas in chemistry and their applications is an element in the functional paradigms of most chemistry teachers.

One cluster of three objectives (1.1, 1.2, and 1.3) in the *Curriculum guide for senior high school chemistry,* refers to developing, "skill in the methods used by chemists". Objective 1.3, which refers to "skill in individual and group problem solving", was ranked third overall (3.59, 0.79); objective 1.1, which refers to developing skill in "processes of scientific inquiry" was ranked sixth (3.42, 0.80); and objective 1.2, referring to "skill in the cognitive, affective and psychomoter domains" ranked eighth (3.27, 0.80). The objective that referred to "problem solving" was ranked highest of the three, suggesting that many chemistry teachers value problem solving as a means of making students more "cognitively competent". The relatively low standard deviations for these ratings indicate that the teachers were fairly consistent in their stated emphases.

Objective 2.4, which refers to, "the tentativeness of chemical theory" was ranked fifth overall (3.44, 0.85). Analysis of a crosstablulation of teacher ratings by teaching experience indicated that less experienced teachers rated objective 2.4 as more important than more experienced teachers (chi-square=3.47, df=1, p=0.0624). Apparently more recently trained teachers place more value on this aspect of chemistry teaching, a finding which is consistent with Kurelek's emphasis on the development of atomic theory. Analysis of a crosstabulation of the ratings of objective 2.4 by area of specialization indicated that teachers with a specialization in the physical sciences emphasize the tentativeness of chemical theory more than other teachers (chi-square=3.28, df=1, p=0.0700).

Generally the objectives which refer to addressing the impact of science and technology on society are ranked low, with none of them ranking higher than tenth. Objectives 3.1, 3.2, and 3.3, all refer to having students acquire a background knowledge about such issues as; "use and depletion of natural resources", "chemistry of environmental pollution", and "use and misuse of chemicals such as preservatives, additives, insecticides". These objectives ranked twelfth, eleventh, and tenth, respectively, in the mean teacher ratings, indicating that chemistry teachers generally do not value the science-technology-society connection. However, the relatively high standard deviation of the ratings for these objectives indicates a fairly wide range of emphases on these objectives among the teachers in the sample.

Objectives 4.1, 4.2, 4.3, and 4.4, all refer to acquiring, "a background of knowledge and experiences in the applications of chemistry" in the following four areas: the home, leisure-time activities, consumer chemistry, and industry. These objectives all received relatively low ratings, ranking ninth, seventeenth, sixteenth, and thirteenth, repectively. Although these objectives all refer to applications of chemistry, which is generally valued, the applications are to social or technological situations which are not valued. Objective 5.0 refers to developing in students, an awareness and critical understanding for decision-making on value issues arising out of the use and misuse of chemistry". As with the other objectives which relate to the impact of science and technology on society, objective 5.0 received a relatively low rating (2.71, 0.92), giving it a rank of fourteenth.

Objective 7.0, which refers to developing in students, "a background of knowledge and skills prerequisite to future careers", ranked seventh in mean teacher ratings (3.40, 1.03), and has the highest standard deviation of any of the objectives. This finding is consistent with the interview data which indicated that only Allan made any effort to inform his students about possible careers in chemistry. Objective 6.0 refers to students acquiring knowledge and appreciation of the history and philosophy of chemistry. The mean and standard deviation of the teacher ratings for this objective

(2.71, 0.88) indicate that the teachers in the sample are quite consistent in their lack of emphasis on this objective. Kurelek was the only one of the three teachers inteviewed who placed any emphasis on the history of chemistry in his classes. Orpwood and Alam (1984) found that the objective, "understanding the history and philosophy of science", was ranked fourteenth out of fourteen, indicating that science teachers generally do not regard this aspect of science teaching as important..

Selecting and Adapting Curriculum Materials

In Section 3 of the CCPS chemistry teachers were asked to indicate the importance they attach to each of fourteen different factors, when selecting and adapting curriculum materials for use in their classrooms. The indications were made by circling a number on a five-point Likert scale, where "1" corresponded to 'not important' and "5" corresponded to 'extremely important'. In Table 19 the fourteen factors are ranked in order of their mean rating, and the standard deviations of the ratings for each item are given. Generally, the ratings of factors considered when selecting and adapting curriculum materials are consistent with the ratings of the objectives of the Alberta chemistry program. For example, in both cases understanding the fundamental principles of chemistry was rated high, and the history of chemistry was rated low. The relatively low standard deviations for all of the ratings indicate considerable agreement among the respondents about the importance of these factors in guiding their selection and adaptation of curriculum materials.

The six highest ranked factors are all fairly close together, apparently all important in determining how teachers interpret curriculum materials for use in their classrooms. The top three factors suggest considerable importance being attached to effectively teaching basic chemical principles (4.24, 0.74), which will enable students to succeed in the next level of chemistry (4.46, 0.66) and in their post-secondary education (4.15, 0.85). These ratings are consistent with MacDonald and Leithwood's (1982) contention that teachers' curriculum decision making is directed toward assisting students in becoming more cognitively competent.

Approaches that have worked well in the past (4.10, 0.65) are seen to be an important factor in guiding teachers' selection and adaptation of curriculum materials.

Table 19

Mean Teacher Ratings of Factors Considered When Selecting and Adapting Curriculum Materials

Rank	Factor Considered	Mean	S.D.
1.	What students need to succeed in the next level of chemistry	4.46	0.66
2.	What students require to understand the principles of chemistry	4.24	0.74
3.	What students need to succeed in their post-secondary education	4.15	0.85
4.	Approaches that have worked well for you in the past	4.10	0.65
5.	The time available	4.09	0.81
6.	The facilities available	4.02	0.89
7.	The guidelines given in the Chemistry Curriculum Guide	3.91	0.75
8.	The students' ability	3.78	0.83
9.	The students' background in science	3.57	0.89
10.	Your own interests, background and preferences	3.57	0.74
11.	What students need to understand the impact of chemistry in their lives	3.52	0.78
12.	What society needs by way of informed citizens	3.41	0.93
13.	What students will enjoy and find personally interesting	3.29	0.75
14.	What students require to understand the historical development of chemistry	2.77	0.81

These ratings suggest that teachers generally have confidence in what Allan would call, "their own pet way of doing things", and that particular techniques, exemplars, and routines are elements in the functional paradigms of teachers that influence the interpretation of curriculum materials. The time (4.09, 0.81) and facilities (4.02. 0.89) available are also seen as important factors, suggesting that many chemistry teachers share Allan's and Jensen's concern about covering the course content and facilities for student experimental work.

The remaining factors all have mean ratings of less than 4.00. The chemistry curriculum guide ranked seventh overall (3.57, 0.89), which is consistent with ratings that senior high school science teachers gave to "ministry policy statements" (seventh out of thirteen) in the Science Council of Canada study (Orpwood and Alam. 1984). It would be interesting to see if the rating of the curriculum guide has changed since mandatory, province-wide final examinations have been reinstated by Alberta Education.

Students' ability (3.78, 0.83) and background in science (3.57, 0.89) ranked eighth and ninth, respectively. Analysis of a crosstabulation of the ratings of student background by teaching experience, indicated that less experienced teachers regard student background as a more important factor than do experienced teachers (chi-square=6.04, df=1, p=0.0139). This corresponds to the interview data where Kurelek was the only teacher who considered the chemistry that students had learned in junior high school when deciding what aspects of the ALCHEM materials to use.

Teaching Strategies

In Section 4 of the CCPS chemistry teachers were asked to indicate how frequently they use particular teaching methods in their chemistry classes. The responses of 68 teachers, summarized in Table 20, indicate that there is a wide range in the frequency of use of most of the teaching strategies listed in the CCPS. For example, the frequency of having students put their homework on the blackboard, a routine used by both Allan and Jensen, was reported as being, "almost every class period", by 9.0% and as, "never or rarely", by 23.9% of the respondents with the remaining teachers distributed among the other categories.

Table 20

Frequency of Use of Various Teaching Strategies

Strategy	Percentage of Respondents Indicating Frequency*				
	A	B	C	D	E
lectures	50.0	39.7	5.9	2.9	1.5
supplementary notes	25.0	35.3	25.0	13.2	1.5
supplementary worksheets	16.2	52.9	26.5	2.9	1.5
personal anecdotes	16.2	41.2	32.4	5.9	4.4
homework on blackboard	9.0	31.3	25.4	10.4	23.9
tests or quizzes	4.5	46.3	47.8	1.5	
lab work		42.6	57.4		
demonstrations		27.9	60.3	10.3	1.5
evaluating lab reports		20.9	55.2	11.9	11.9
films or videotapes		9.0	43.3	31.3	16.4
newspapers or magazines		6.0	26.9	31.3	35.8
supplementary lab work		4.4	17.6	44.1	33.8
computers				9.0	91.0
guest speakers				9.0	91.0
field trips				6.0	94.0

*
A. almost every class period
B. about once or twice a week
C. about once or twice a month
D. about once or twice a semester
E. never or rarely

The responses indicate that the four most frequently used teaching strategies are lectures, supplementary notes, supplementary worksheets, and personal anecdotes, with well over half of the teachers indicating that they use these strategies as least once a week. These findings are consistent with those of the SISS (Canada) teacher perception study (Connelly, Crocker & Kass, 1984), which found that teacher presentation was the dominant form of instruction in Canadian science classrooms. The relatively high frequency of use of personal anecdotes suggests that "exemplars" are an important element in the functional paradigms of teachers. For purposes of comparison, the range of frequencies of use was collapsed to two categories, weekly or more often, and monthly or less often. Crosstabulations were done to compare chemistry majors with non-majors, using the two frequency categories, and significant chi-squares were found for two of the teaching strategies. Chemistry majors reported using their own worksheets (chi-square=7.79, df=1, p=0.0053), and supplementary notes (chi-square=7.35, df=1, p=0.0067) more often than non-majors. It seems reasonable that teachers with a stronger chemistry background would generate more of their own materials than teachers with a weaker background.

About half (50.8%) of the respondents report using tests and quizzes at least weekly, while about half (52.3%) report using films and videotapes at least monthly. Analysis of a crosstabulation of frequency of use by number of students taught, indicated that teachers who teach 100 or more students use tests and quizzes (chi-square=4.47, df=1, p=0.0344), and films and video tapes (chi-square=4.87, df=1, p=0.0274) more often than teachers who teach less than 100 students. Perhaps frequent testing and use of films are "survival techniques" that teachers use for coping with large numbers of students. This interpretation would be consistent with Stake and Easley's (1978) hypothesis that what teachers do with subject matter is largely determined by how it sustains and protects them in the social system of the school. Over half (57.4%) of the chemistry teachers report doing laboratory work once or twice a month, with the remainder (42.6%) doing laboratory work once or twice a week. Apparently laboratory work is not evaluated each time students are in the lab, since the frequency of evaluating lab reports is much less than the frequency of doing lab work.

That over one third (35.8%) of the respondents indicated that they never or rarely use newspapers or magazines in their chemistry classes is consistent with the low ratings given to teaching students about the impact of chemistry on their daily life, reported in the previous section. Over 90% of the chemistry teachers in the sample indicate that they never or rarely use computers, guest speakers, and field trips in their chemistry classes. Apparently, teachers feel that the pedagogical value of these teaching strategies isn't worth the time and effort required to arrange to use them.

Teacher Use of ALCHEM materials

Immediately prior to Section 5 of the CCPS, teachers were asked if they had ever used any of the ALCHEM materials in teaching high school chemistry. Of the 69 teachers who completed the CCPS questionnaire, 65 (94.2%) indicated that they had used ALCHEM and 4 (5.8%) indicated that they had never used ALCHEM. Only the teachers who had used ALCHEM were asked to complete the remaining two sections of the questionnaire. The responses of the ALCHEM users are summarized in Table 21, as percentages of the total respondents, as well as separately for the chemistry majors and non-majors.

Over half (58.7%) of the respondents indicated that they have been using ALCHEM materials for over three years, with little difference between the years of use between the chem majors and non-majors. The slighty larger proportion of non-majors (17.9%) than chem majors (12.5%) who report using ALCHEM materials for only one year, could be due to some of the non-majors having moved into teaching chemistry within the last year, as a result of a change in teaching assignment.

Teachers were asked to indicate the courses in which they had used ALCHEM. Since most teachers use ALCHEM in more than one course, the percentages in the corresponding part of Table 21 will total more than 100. Overall, 90.5% of the respondents report using ALCHEM in Chemistry 10; 92.1% in Chemistry 20; and 61.9% in Chemistry 30. Clearly, the ALCHEM materials are more widely used for teaching Chemistry 10 and 20 than they are for Chemistry 30.

Over half (54.0%) of the respondents report using ALCHEM exclusively as a textbook. A somewhat smaller proportion of the chemistry majors (45.0%) than non-majors (69.6%) report using ALCHEM in this way. Of the total respondents, 12.7%

Table 21

Teacher Use of ALCHEM Materials

	Percent of Non-Majors	Percent of Chem Majors	Percent of Respondents
Years Using ALCHEM			
1 year	17.4	12.5	14.3
2 - 3 years	26.1	27.5	27.0
4 - 5 years	47.8	35.0	39.7
6 - 7 years	8.7	15.0	12.7
8 years or more	0.0	10.0	6.3
(N)	(23)	(40)	(63)
Courses in Which ALCHEM Used			
Chemistry 10	82.6	95.0	90.5
Chemistry 20	87.0	95.0	92.1
Chemistry 30	60.9	62.5	61.9
Science 11	4.3	0.0	1.6
(N)	(23)	(40)	(63)
Description of ALCHEM Use			
As a textbook	69.6	45.0	54.0
With another text	8.7	17.5	14.3
To supplement another text	4.3	17.5	12.7
Combination of above	17.4	20.0	19.1
(N)	(23)	(40)	(63)
Overall rating of ALCHEM			
Excellent	39.1	27.5	31.7
Good	39.1	37.5	38.1
Satisfactory	17.4	25.0	22.2
Unsatisfactory	4.3	7.5	6.3
Very Unsatisfactory	0.0	2.5	1.6
(N)	(23)	(40)	(63)

described their use of ALCHEM as, "in conjunction with another text", with 17.5% of the chemistry majors using this description compared to 8.7% of the non-majors. Of the total respondents, 12.7% described their use of ALCHEM as, "selected pages to supplement another text". More of the chemistry majors (17.5%) used this description than did the non-majors (4.3%). Approximately one-fifth (19.1%) of the respondents described their use of ALCHEM by using some combination of the three descriptions listed in that item on the CCPS. All of these combinations include using ALCHEM as a textbook. Presumably, combinations of descriptions were used by teachers who use ALCHEM differently with different classes. For example, a teacher might use ALCHEM materials as a textbook in Chemistry 10 and 20, and to supplement another text in Chemistry 30. Overall, the responses to the CCPS items suggest that chemistry majors are more inclined than non-majors to use a combination of curriculum materials in their classroom practice.

On the overall rating of ALCHEM, 69.8% of the teachers rated the materials as good or excellent, while 7.9% rated them as less than satisfactory. Generally the chemistry majors did not rate ALCHEM as high as did the non-majors. Of the chemistry majors, 65.0% rated ALCHEM as good or excellent and 10.0% as less than satisfactory, compared to 78.2% and 4.3% for the non-majors. It should be pointed out again that the focus of the current study is not to evaluate the ALCHEM materials, but to use them as a "strategic site" to study chemistry teachers' functional paradigms as represented by the way they interpret curriculum materials.

The next 12 items in Section 5 of the CCPS parallel the items in the Student Opinion Survey (SOS). Teachers were asked to rank, on a five-point scale, twelve different aspects of the ALCHEM materials on the basis of their usefulness in teaching high school chemistry. The mean and standard deviation of the ratings for each aspect are given in Table 22, where the aspects are ranked in order of their mean rating. The teacher ratings of ALCHEM are very similar to those done by the students in the chemistry classes of Allan, Jensen, and Kurelek which were reported and discussed earlier. The periodic table is rated as the most useful (4.68, 0.50) part of ALCHEM for teaching high school chemistry. Some of the student exercises, such as "problem worksheets" (4.11, 1.02) and "overview exercises" (4.09, 0.88) are rated high; while others, such as, "completion of tables" (3.60, 1.07) and "lab work" (3.52, 1.18) are rated somewhat lower. As with the

Table 22

Teacher Ratings of the ALCHEM Material

Rank	Aspect of ALCHEM	Mean	S.D.
1.	periodic table provided in ALCHEM text	4.68	0.50
2.	worksheets which require solving problems	4.11	1.02
3.	overview exercises at end of each unit	4.09	0.88
4.	worked out examples of problems (sample solutions)	3.75	1.12
5.	information about sources and uses of chemicals	3.68	0.90
6.	demonstrations	3.60	1.13
7.	worksheets which require completion of tables	3.60	1.07
8.	objectives listed at the beginning of each unit	3.54	1.13
9.	lab work	3.52	1.18
10.	explanation of chemical concepts and principles	3.40	0.98
11.	illustrations	3.03	1.09
12.	biographical sketches	2.94	1.04

students, the ALCHEM illustrations (3.03, 1.09) and biographical sketches (2.94, 1.04) are ranked at the bottom. The standard deviation of several of the items is greater than one, indicating a fairly wide range of opinion about the usefulness of that particular aspect of ALCHEM for teaching high school chemistry. It is interesting to note that the standard deviations of the ratings of the ALCHEM materials are generally higher than those of the objectives of the Alberta chemistry program, and of the factors considered when selecting and adapting curriculum materials. It seems that differences among the opinions of teachers are more apparent when they are responding to questions about specific materials than when they are responding to questions about generalized objectives or factors.

Discriminant analysis of the ALCHEM ratings was done as a means of probing the apparent differences of opinion among the respondents regarding various aspects of the ALCHEM materials. An outline of the discriminant analysis procedure is given in Chapter 3, and a summary of the discriminant analysis of the CCPS data is given in Table 23. The respondents were divided into two groups on the basis of their ratings on the CCPS items relating to ALCHEM worksheets and sample solutions. Those who gave average ratings of 4.0 or greater were placed in one group, and those who gave average ratings of less than 4.0 were placed in the other. A step-wise discriminant analysis program from the SPSS library (Nie et al, 1975) was used to select the best set of predictors from the set of demographic variables included in Section 1 of the CCPS.

Four predictors were selected: sex of the teacher, the number of teachers in the school, the number of years experience teaching chemistry, and the number of students taught. The positive value of the discriminant equation coefficient for sex of teacher indicates that female teachers tended to to be in the group that rated the worksheets and sample solutions higher, and that the males tended to be in the group that rated them lower. The negative value of the coefficient for the number of teachers in the school indicates that teachers in larger schools tended to rate the worksheets and sample solutions lower than teachers in smaller schools. Perhaps teachers in the larger schools are in a position to draw from other resources and don't rely on this aspect of the ALCHEM materials as much as teachers in smaller schools. Recall that the science department at Rutherford had a storage room filled with supplementary chemistry

Table 23

Summary of Stepwise Discriminant Analysis of Teacher Groups

Ratings of ALCHEM Worksheets

Variable Entering	Total F Value	Significance	Discriminant Equation Coefficient
1. sex of teacher	7.48	0.008	0.775
2. teachers in school	4.46	0.016	-0.631
3. chem teach. exper.	3.52	0.021	-0.362
4. students taught	3.00	0.026	0.403
After Function			
chi-square	11.07		
degrees of freedom	4		
significance	0.026		
canonical correlation	0.424		
cases correctly classified	65.1%		

Ratings of ALCHEM Demonstrations and Laboratory Work

Variable Entering	Total F Value	Significance	Discriminant Equation Coefficient
1. students taught	3.61	0.062	1.154
2. teachers in school	4.64	0.014	-0.951
After Function			
chi-square	8.60		
degrees of freedom	2		
significance	0.014		
canonical correlation	0.374		
cases correctly classified	67.2%		

worksheets. The negative value of the coefficient for chemistry teaching experience indicates that more experienced teachers rated this aspect of the ALCHEM materials lower than less experienced teachers. As with teachers in larger schools, it seems likely that more experienced teachers would have a larger accumulated supply of resource materials to draw from than would less experienced teachers and would, consequently, not rely on ALCHEM as much is this regard. Another possibility is that more experienced teachers have more definite ideas about appropriate problem solving approaches, and may not agree with the approach outlined in the ALCHEM sample solutions. Recall that Allan took exception to the "formula substitution" approach in the ALCHEM sample solutions. The positive coefficient for the number of students taught indicates that teachers with larger numbers of students rate this aspect of ALCHEM higher than teachers with fewer students. This may indicate that worksheets are a survival technique used by teachers to cope with large numbers of students. Overall, these data suggest that teachers' interpretation of curriculum materials is influenced considerably by their background and by their teaching situation.

The CCPS respondents were also divided into two groups on basis of their ratings of the demonstrations and laboratory work in the ALCHEM materials. Those respondents who gave these aspects of ALCHEM an average rating of 4.0 or greater were placed in one group, and those whose average rating was less than 4.0 were placed in the other. The positive value of the discriminant equation coefficient for the "number of students taught variable", indicates that teachers who teach large numbers of students appreciate the demonstrations and laboratory work in ALCHEM more than teachers with smaller numbers of students. The negative value of the coefficient for the "number of teachers in the school" variable indicates that teachers in larger schools do not rate these aspects of ALCHEM as high as teachers in smaller schools. The same interpretation seems appropriate here as for the worksheets, that is, that teachers who teach large numbers of students appreciate the convenient format of the ALCHEM materials, while teachers in larger schools have other resources to draw upon and do not rely on ALCHEM to the same degree as teachers in smaller schools.

Responses to CCPS Open-Ended Questions

In Section 6 of the CCPS the first five questions were designed to parallel the guiding questions used in the interviews with Allan, Jensen, and Kurelek. Table 24 summarizes teacher responses to the first of these questions, in which teachers were asked to give their opinion of the ALCHEM materials. Since some of the teachers made more than one point in their response, the total number of responses (112) is greater than the number of teachers who completed this section of the CCPS (65). Of the 39 teachers who gave their response in terms of a general rating, 31 rated ALCHEM as good, very good or excellent, while 7 rated it as generally favorable or adequate and one as poor. These comments are generally consistent with the distribution of responses on the earlier Likert-scale item on the CCPS, where teachers were asked to give an overall rating of the ALCHEM materials.

The remaining responses are categorized as they refer to chemistry, to teaching, to students, and to school setting. Many of the statements are in direct contradiction to each other. As much as possible, contradictory statements are placed side by side in the table. Although many of the teachers' responses are given as evaluations of ALCHEM, it is what these responses reveal about teachers' functional paradigms that is of interest in the current study, not an evaluation of the ALCHEM materials.

Many of the comments (49) in this section were given in terms of teaching considerations. The lack of detail in the ALCHEM explanatory materials is mentioned as a weakness by fourteen teachers while four others regard its straightforward presentation of basic concepts as a strength. There seems to be a difference of opinion among chemistry teachers regarding what constitutes adequate depth of coverage in high school chemistry, and what the role of curriculum materials is in providing resource material. Ten teachers commented that they disapprove of the workbook format of the ALCHEM materials, while seven others mentioned the large number of suitable exercises as a positive feature of ALCHEM. While teachers generally seem to appreciate the availability of suitable student exercises, some teachers express the view that repetitous, "type problems", do not promote student thinking. These comments also reflect differing views of curriculum materials. Should curriculum materials provide all the necessary background as well as an abundance of student exercises? One veteran teacher in a large urban school

Table 24

Summary of Teachers' Responses to the CCPS Question,

"In general, what is your opinion of the ALCHEM materials?"

Teachers' Responses (65 teachers responded to this question)	Response Frequency
Responses Given as Ratings	
-excellent	14
-very good	8
-good	9
-generally favorable	4
-satisfactory / adequate	3
-poor	1
Responses Given in Terms of Chemistry	
-applied chemistry is good	2
-too little theory	2
-good presentation of major concepts in chemistry	1
-inadequate presentation of the nature of science	1
-incomplete presentation of organic chemistry	1
Responses Given in Terms of Teaching	
-more depth required / needs supplementing / inadequate as a reference	14
-straightforward basics / "everything laid out in front of them"	4
-promotes rote use of "workbook" / problems too repetitive / don't promote thinking / poor problem solving approach	10
-good worksheets / large number of suitable exercises	7
-good supplementary material	4
-well organized materials / "thought out" and interrelated	4
-allows for flexible teaching approach	2
-consistent use of conventions	1
-labs should be more developmental	1
-more exercises needed for additional practice	1
-suitable to the curriculum	1
Responses Given in Terms of Students	
-students like them / find them interesting and organized	4
-easier for student / can be sucessful	3
-geared to lazy student / false sense of success / little math skill required	3
-suitable to level of student	2
-confusing information / too long and difficult for students	2
-students can use as a text and a workbook	1
Responses Given in Terms of School Setting	
-materials for labs are not available	1
-labs are suitable to materials available	1

addressed this question while stating his general support for the format of the ALCHEM materials.

> Some concepts require a greater depth but in general the material is good to excellent. Since no single material constitutes the curriculum or is able to completely satisfy curricular requirements or individual interests, ALCHEM materials may be somewhat sketchy in certain concept areas but does allow for individuals to supplement those areas if so inclined. I don't think that a revision should necessarily expand certain concept areas to satisfy critics as the flexibility will still be inherent and utilized to satisfy individual needs. In general ALCHEM is well organized, includes excellent examples and provides clues for meaningful discussions and extension. Optional topics and remedial exercises are an excellent feature whether used or not.

Of the responses to CCPS item 84, 15 were given in terms of students. The teachers comments seem to reflect a range of perceptions about the interests, needs, and abilities of students. The differing perceptions are likely due to real variations among the students, as well as to differences in the way that different teachers would view the same students. Teaching students with a range of interests, needs, and abilities in the same class was a problem mentioned by some of the respondents. One teacher from a large urban high school commented that ALCHEM was, "a good workbook for the average to below average student", but did not provide, "enough challenge for the above average student".

Table 25 summarizes the teacher responses to the CCPS question, "Are there any parts of ALCHEM that you omit? (e.g., labs, demos, exercises). If so, what are they and why do you omit them?" Item 87 on the CCPS asked teachers to comment on any modifications that they made to the ALCHEM materials. Any of the responses to item 87 which referred to omitting parts of the materials, as a means of modifying, are tallied in Table 25 as well. Of the 54 teachers who responded to this item, 13 stated that they omit nothing from ALCHEM. Omitting student laboratory activities was mentioned by 23 teachers, most of whom did not specify which labs. Among the teachers who did specify the labs that they omit, no lab was mentioned more than once. Omission of topics designated as "elective" (i.e., not part of the core program as outlined in the Alberta chemistry curriculum guide) was mentioned by 16 teachers. Again, most respondents did not specify which elective topics they omit, and there were no common topics among those who did.

Table 25

Summary of Teachers' Responses to the CCPS Question,

"Are there any parts of ALCHEM that you omit?"

Teachers Responses (54 teachers responded to this question)	Response Frequency
-certain labs	23
-certain elective topics	16
-omit nothing	13
-certain core topics	2
Reason for Omission Given in Terms of Chemistry	
-prefer applied chemistry over theoretical chemistry	1
Reason for Omission Given in Terms of Teaching	
-lack of time	14
-lab or demo out of sequence / inappropriate / ineffective	8
-exercises don't teach thinking or writing skills	4
-choose to do other elective material	2
-exercises are repetitious	1
Reason for Omission Given in Terms of Students	
-too difficult for ability of class	2
Reason for Omission Given in Terms of School Setting	
-lack of materials / equipment	8

Lack of time was mentioned by 14 teachers as the reason for omitting parts of ALCHEM, suggesting that many teachers feel the pressure of time that both Allan and Jensen mention in the interviews reported earlier. That lack of time is given as a reason for omission, suggests that teachers consider elective material and student laboratory work to be worthwhile but that they consider emphasis on the core content to be more important.

Lack of effectiveness as a teaching strategy was mentioned by eight respondents as the reason they omitted particular student laboratory experiments and/or teacher demonstrations. One teacher in an urban school expressed the following view:

> Labs in Chem 10 and Chem 20 are such that the students do little but go through the motions with little attempt to conceptualize or generalize what is happening. I therefore find that the students get more out of a good demonstrating than these "Mickey Mouse" labs.

The "lack of effectiveness" viewpoint seems to assume that the only function of student laboratory work is to assist the teaching of chemical theory. Lab work as a means of motivating students or teaching process skills was not acknowledged in any of the comments.

Another factor seems to be the teacher's perception of the suitability of the curriculum materials for a particular class. One urban teacher outlined how variations in student ability and interest influence use of curriculum materials in her classroom.

> I sometimes omit or substitute material for a variety of reasons - ability of the class - some need more review or practice, others need to explore extensions. The (ALCHEM) text is the only resource I use. When exercises are omitted it is not a reflection on their quality, rather that I have chosen to emphasize something else. Much of the optional material I omit. I use this time for other electives.

Lack of equipment for experimental work was mentioned by eight teachers as the reason they omit some of the student laboratory work and teacher demonstrations. The following comments are from three different teachers, all working in rural schools.

> Some demos and labs require equipment and chemicals that our lab does not have. The general labs such as "chemical reactions" with many short experiments are preferable as parts (for which we do not have the materials) are omitted, not the entire lab.

> Lab work is very difficult because of the facilities that my classroom is

equipped with.

> I don't use the labs, demos, or exercises. Labs don't fit the equipment and classroom that I have. Demos can't be seen in my classroom. Exercises can't be graded daily.

The comments of these rural teachers are consistent with the responses to an earlier CCPS item where rural teachers rated their schools' facilities for teaching chemistry lower than did urban teachers. Overall, the teachers' responses to CCPS item 85 are consistent with a valuing of, "the fundamental ideas in chemistry", which seems to mean theoretical chemistry content.

Table 26 summarizes teachers' responses item 86 in the CCPS questionnaire, "Are there any parts of ALCHEM that you supplement? (e.g., with films, additional notes, labs, or demos) If so, what are they and how do you supplement them?" Responses to CCPS item 87 which describe modifications to ALCHEM in terms of supplementing are included in Table 26 as well. Most of the responses are given in terms of chemistry topics. Two of the most frequently mentioned, equilibrium (17) and reaction kinetics (11) are not part of the core program as outlined in the Alberta chemistry curriculum guide, and are not dealt with in any detail in the ALCHEM materials. Three other frequently mentioned topics, organic chemistry (12) atomic structure (10) and stoichiometry (10) are part of the core program, but many teachers feel the need to supplement the treatment given these topics in the ALCHEM materials. Apparently many teachers feel that these five topics are an essential part of high school chemistry and are willing to go beyond the stated curriculum to provide their students with a thorough grounding in these topics.

Films and videotapes are the most frequently mentioned means of supplementing. Most teachers did not mention specific films, however, one teacher attached four handwritten pages to the CCPS questionnaire, on which he listed 54 films, 22 filmstrips, and 15 video cassettes which he uses regularly. Each item was referenced to a specific ALCHEM unit. This teacher works in a centralized school in a rural community where he teaches over 200 students. As observed earlier, films and videotapes are used more extensively by teachers with heavier teaching loads.

Teacher developed worksheets were mentioned by twelve teachers, suggesting that the worksheet format is valued by many teachers as an effective means of

Table 26

Summary of Teachers' Responses to the CCPS Question,

"Are there any parts of ALCHEM that you supplement?"

Teachers' Responses (54 teachers responded to this question)	Response Frequency
-don't supplement	3
Responses Given in Terms of Chemistry Topics	
-equilibrium	17
-organic chemistry	12
-reaction kinetics	11
-atomic structure	10
-stoichiometry	10
-acids and bases	7
-bonding	7
-mole concept	7
-energy	6
-solutions	5
-formula writing	4
-oxidation number	4
-applied chemistry	3
-nature of science	2
Responses Given in Terms of Teaching Strategies	
-films or videotapes	15
-own worksheets	12
-lab work or demonstrations	7
-supplementary references / other texts	5
-supplementary notes	5
-lectures	3
Reasons for Supplementing	
-to stimulate and challenge	9
-to enrich / add detail	6

supplementing curriculum materials. The reasons mentioned for supplementing were to stimulate and challenge (9) or to enrich and add detail (6). One teacher expressed his reasons in this way:

> . . . extra worksheets with more than just a single formula for that particular section. To make students think about which formula to use, rather than just plugging the one into every single problem on the page.

The reasons given for supplementing seem to be consistent with a valuing of academic rigor.

Teachers responses to the CCPS item 88, which asked teachers to indicate which elective units they use and how much time they spend on them, are given in Table 27. Eighteen teachers indicated that they extend a core topic or do a core topic in depth in lieu of covering an elective unit. A total of 14 teachers responded that they didn't use electives or that they didn t have time for electives, which is interpreted to mean that they value expanding and emphasizing the core material more than teaching an elective topic. The 12 teachers who indicated that they use locally developed materials did not specify what topics these materials covered. Of the ALCHEM units, those that deal with nuclear chemistry and analytical chemistry are the most widely used, possibly because of the student interest in these topics that Jensen and Kurelek noted.

That 32 out of 54 teachers (59%) use the time allotted for elective material to expand on core topics, suggests that many teachers value theoretical chemistry over applied chemistry. In addition, many of the topics listed as elective emhasize chemistry theory (e.g., reaction rates, equilibrium, gas laws). These observations are consistent with the general lack of emphasis in Canadian science education on the relationships among science, technology, and society (Science Council of Canada, 1984).

For the last two questions on the CCPS, teachers were told that a major revision of the ALCHEM materials is planned for the near future. The teachers were then asked to indicate what they thought should be added to or removed from the materials. A summary of teachers' indications of what should be added to the revised ALCHEM materials is given in Table 28. The responses summarized in Table 28 seem to be generally consistent with those given to earlier questions. The chemistry topics listed are taken as an indication of what many teachers consider to be required components of a good high school chemistry

Table 27

Summary of Teachers' Responses to the CCPS Question,

"Which elective units do you use?"

Teachers' Responses (54 teachers responded to this question)	Response Frequency
Comments on Electives	
-extension of core topic / core in depth	18
-don't use electives	9
-no time for electives	5
Elective Topics	
-Nuclear Chemistry(ALCHEM)	16
-Analytical Chemistry(ALCHEM)	13
-locally developed materials	12
-rates of reaction	9
-Food and Their Analogs(ALCHEM)	7
-Metallurgy and Corrosion(ALCHEM)	7
-Athabasca Tar Sands(ALCHEM)	6
-equilibrium	6
-gas laws	5
-Alberta Chemical Industries(ALCHEM)	5
-Ethylene and Its Derivatives(ALCHEM)	3

Table 28

Summary of Teachers' Responses to the CCPS Question,

"What should be added to the revised ALCHEM materials?"

Teachers' Responses (46 teachers responded to this question)	Response Frequency
Responses Given in Terms of Chemistry	
-equilibrium	16
-gas laws	12
-reaction rates	11
-more and better lab activities	8
-organic chemistry	6
-nature of science	4
-atomic structure	3
-energy	3
-electrochemistry	3
-mole concept	2
-stoichiometry	2
-solution chemistry	2
-formula writing	1
-acids and bases	1
-bonding	1
Responses Given in Terms of Teaching	
-more resources (e.g., films lists, supplementary reading)	4
-more overview	3
-don't add anything / too rushed already	2
-unit analysis approach to problem solving	2
-change sequence of topics	1
Responses Given in Terms of Students	
-get students to think	5
-application to daily life	3

program. Again, equilibrium, gas laws and reaction rates are frequently mentioned as topics that should be added. Overall, the responses to this item suggest that most teachers value theoretical chemistry over applications of chemistry to social or technological situations. One teacher in an urban school expressed what appears to be a minority opinion.

> Anything that could be suggested for making the program less theoretical - more concrete, more practical would be appreciated. Teachers are not doing extensive elective units so perhaps increasing the number and variety of options in the material would be useful. Suggestions for remedial or enrichment activities (idea bank) could be added to the teachers' guide.

The items that teachers suggested removing from the ALCHEM materials are summarized in Table 29. Of the 41 teachers who responded to the question, 15 indicated that nothing should be removed. The remaining responses refer to chemistry (12) and teaching (16). Some teachers seem to want items removed if they don't use them, while others regard the materials as a resource which they are free to use or not use. An urban teacher expressed the following view:

> I don't think anything has to be removed. It is the teacher's responsibility to select from what is available. There is no reason to use everything that is included. Perhaps the Teacher's Guide could take on the "resource book" image rather than "answer key".

The problem of time constraints is reflected in some of the responses to CCPS items 89 and 90. An experienced teacher in an rural school expressed the opinion that more time should be allowed for science courses in the school program.

> I am of the opinion that with the new developing technologies, students should spend more study time in the Sciences not Social Studies.
> Solution: Chemistry 10 and 20 for 5 credits.
> Rather than removal, there should probably be additions to the High and Junior High School Program.

Although this teacher seems to see a connection between science and technology, he does not seem to see a connection between science and society.

Table 29

Summary of Teachers' Responses to the CCPS Question,

"What items should be removed from the ALCHEM materials?"

Teachers' Responses (41 teachers responded to this question)	Response Frequency
-don't remove anything	15
Responses Given in Terms of Chemistry	
-aromatic hydrocarbons	3
-percent dissociation	2
-certain symbols	2
-classical nomenclature	2
-bonding unit (if possible)	1
-significant figures	1
-shorten Unit A (elements and periodic table)	1
Responses Given in Terms of Teaching	
-repetitious exercises	4
-background information on chemicals	3
-formula approach to problem solving	3
-certain labs	2
-historical aspects	1
-cartoons	1
-workbook format	1
-authoritarian dogmatic approach	1

C. Summary of Chemistry Classroom Practice Survey

The demographic data collected by the CCPS questionniare indicate that Alberta chemistry teachers are predominantly middle-aged males. The estimated age of teachers in the sample is 39, with over two-thirds (67.6%) of the male teachers being over 35. The female teachers, who comprise only 17.6% of the sample, are somewhat younger and better trained than the males, and tend to be concentrated in the large urban senior high schools. Data from the questionnaire also indicate that Alberta chemistry teachers are highly experienced, with nearly three-quarters (72.0%) of the sample reporting a decade or more of teaching experience. A somewhat smaller proportion (52.9%) reported that much experience at teaching chemistry, suggesting that many teachers have moved into teaching chemistry recently, possibly as a result of shifts in teaching assignment which have accompanied declining enrollments in many schools. The demographic data captured by the CCPS questionnaire are consistent with the corresponding data collected in both the Science Council of Canada study (Orpwood & Alam, 1984) and the Canadian component of the SISS study (Connelly, Crocker & Kass, 1984).

The data from the CCPS suggest some significant differences in the teaching situations of the rural and urban teachers who comprise nearly equal proportions of the sample. While urban teachers are required to teach larger numbers of students in a given semester, rural teachers are required to teach more different courses. Specialization in chemistry, both in terms of training and teaching assignment, is more frequent in urban than in rural schools. As a consequence, the teachers with the most training in chemistry are teaching the largest number of chemistry students.

Analysis of the CCPS data indicated some elements which seem to be common to the functional paradigms of most chemistry teachers. An important element in the functional paradigms of nearly all the chemistry teachers in the sample is the high value placed on major concepts in theoretical chemistry and the application of these concepts to solving mathematical problems. Closely related, is a valuing of methods for effectively teaching basic chemical principles which will enable students to succeed at the next level of chemistry and in post-secondary education. The CCPS responses also indicate that chemistry teachers generally do not value teaching their students about the relationships among science, society, and technology (STS), although there is a fairly wide range of opinion on this matter. Data from the current study also indicate that most chemistry teachers place little value on teaching their classes about the nature of science, i.e., the history, philosophy, and process of science. The predominant interpretive pattern among Alberta chemistry teachers seems to be to emphasize and expand on theoretical chemistry at the expense of applied chemistry.

The findings of the current study regarding the relative value attached to theoretical chemistry, STS interaction, and the nature of science, are consistent with the findings of other recent studies of Canadian science teachers (Brauer, 1981; Orpwood & Alam, 1984;) These findings suggest that the current efforts in chemistry education to generate curriculum materials which emphasize both the social context of science and the nature of science are not likely to have much impact on classroom practice. If chemistry teachers do not value these aspects of teaching chemistry, they will not likely carry these emphases through into their classroom practice.

Teachers responses to the CCPS items regarding objectives of the Alberta chemistry program, selecting and adapting curriculum materials, teaching strategies, and use of the ALCHEM materials, reveal some consistent themes in teachers' interpretation of curriculum materials. The agreement among the data from the various sections of the CCPS attests to the reliability of the survey questionnaire. The validity of the data from the CCPS instrument is indicated by its agreement with data from comparable studies (Brauer, 1981; Orpwood & Alam, 1984, Connelly, Crocker & Kass, 1984). Data from the CCPS questionnaire reveal some predominant patterns in teachers' interpretation of curriculum materials. From these interpretive patterns some inferences can be made about the nature of teachers' functional paradigms. The chemistry teachers in the survey sample seem to be unanimous in accepting the core topics outlined in the Alberta chemistry curriculum guide as essential components in a high school chemistry program. That some of the core topics are particularly valued is indicated by teachers dealing with them is more depth and detail than that given in the ALCHEM materials. The CCPS data indicate three such topics: atomic structure, stoichiometry, and organic chemistry. In addition, many teachers supplement the core program with the following topics: chemical equilibrium, reaction rates, and gas laws. It seems that many teachers believe these topics to be essential components of high school chemistry.

Teaching considerations seem to dominate interpretations of curriculum materials for most teachers. Lack of effectiveness for teaching purposes is often given as a reason for not using specific aspects of the ALCHEM materials. In this regard, considerable value seems to be placed on both academic rigor and pedagogical efficiency. The valuing of academic rigor is reflected by the frequent calls for more depth and detail in the ALCHEM explanatory materials and more challenging questions in the ALCHEM problem sets. This finding is consistent with the research of MacDonald and Leithwood (1982) who found that teachers' curriculum decision-making is dominated by a drive to make students more cognitively competent. Academic rigor is seen to be a means of promoting the cognitive competence of students. The emphasis on academic rigor may also be interpreted as using science knowledge as a means of socializing students and maintaining the teacher's position of authority in the school (Stake & Easley, 1977; Aikenhead, 1983). The high value placed on pedagogical efficiency is indicated by teachers' appreciation of an abundant supply of worksheets and laboratory exercises which can be evaluated quickly.

Closely related to teaching considerations are values and beliefs concerning students' interests and abilities. Inappropriateness for students' level of ability was frequently mentioned as a reason for omitting specific aspects of the ALCHEM materials, and students' interests were given as a reason for selecting a particular elective or using a particular activity. Apparently some teachers believe that students' abilities and interests are important factors to consider in selecting and adapting curriculum materials, although the CCPS items specifically relating to these factors did not have a high mean rating.

The CCPS data indicate that teachers have a great deal of confidence in approaches that have worked well for them in the past, suggesting that each teacher has a body of "techniques, exemplars, and routines" which are part of their functional paradigms. The considerable range in the frequency of use of specific teaching strategies suggests that different teachers find that differents approaches work well for them. The most frequently used teaching techniques are lecture, supplementary notes, and worksheets, which is consistent with other recent studies which found that teacher presentation is the dominant form of instruction in Canadian science classrooms (Orpwood & Alam, 1984; Connelly, Crocker, & Kass, 1984). The least frequently used teaching techniques are computers, guest speakers, and field trips. The frequency of use of various teaching strategies seems to be consistent with the high value placed on theoretical chemistry and problem solving and the lower value placed on the relationships among science, society, and technology that was mentioned earlier.

Analysis of the CCPS data gives some indication of which factors shape teachers' functional paradigms. The chemistry majors in the survey sample rated the adequacy of their background for teaching high school chemistry higher than did the non-majors, particulary with regard to laboratory work. The chemistry majors generally gave lower ratings to the ALCHEM materials than did the non-majors, and were more inclined to use ALCHEM in conjunction with another textbook. The chemistry majors also reported providing their students with supplementary notes and teacher developed worksheets more frequently than did the non-majors. As one might expect, teachers with more training in chemistry seem to be more critical in evaluating and selecting curriculum materials, and to be more inclined to generate their own materials than are teachers with less training in chemistry. Aikenhead (1983) has observed that teachers' experience in science courses at university seems to be a major factor in determining what teachers feel students should get out of high school science courses. The interview data from the current study are consistent with Aikenhead's observation.

Teaching experience also seems to be a factor in determining how teachers interpret curriculum materials. More experienced teachers report having students do experimental work more frequently than do less experienced teachers. On the other hand, the less experienced teachers rate the usefulness of the ALCHEM worksheets and sample solutions higher than did the more experienced teachers, suggesting that as teachers gain experience they also gather resources which make them less dependent on the curriculum materials authorized by the school authorities. Since the topics that many teachers cover under supplementary or elective material are often from previous Alberta chemistry programs, it seems likely that teachers perceptions of an adequate chemistry program are shaped, at least to some degree, by the previous high school chemistry courses that they have taught. While students' background is not generally perceived as an important factor to consider when selecting and adapting curriculum material, less experienced teachers consider students' background to be more important than do more experienced teachers. These findings are consistent with Brauer's (1981) observation that Chemistry 20 teachers relied heavily on their own interests and experiences in making curricular decisions.

Teaching situation seems to provide another set of factors which influence teacher's interpretation of curriculum materials. The school's facilities for teaching chemistry was rated as an important factor in selecting and adapting curriculum materials, lack of adequate laboratory facilities was frequently mentioned as a reason for not doing experimental work. Teachers in rural schools generally rated the adequacy of their schools facilities lower than did teachers in urban schools, and more frequently gave inadequate facilities as a reason for omitting laboratory activities from the ALCHEM materials. Teachers who teach larger numbers of students, reported using films and video tapes more often, and rated the usefulness of the ALCHEM worksheets, sample solutions, laboratory activites, and demonstrations higher than did teachers with smaller numbers of students. These data suggest that these curriculum materials are part of a strategy for coping with large numbers of students. Teachers in smaller schools tended to rate the usefulness of the ALCHEM worksheets, sample solutions, laboratory activites, and demonstrations higher than did teachers in larger schools, possibly because larger schools provide more additional resources for classroom teachers than do smaller schools. Overall, the data suggest that teachers' functional paradigms have more influence on how curriculum materials are translated into classroom practice than do situational factors; which is consistent with Brauer's (1981) finding that Chemistry 20 teachers' own value system and concept of curriculum is a more important factor in curriculum decision-making than are situational variables. In addition, the interview and survey data from the current study support Brauer's (1981) finding of a "consensus effect" within schools that have more than one chemistry teacher.

V. Summary, Major Findings, and Recommendations

In this chapter the method of data collection and analysis are reviewed and the research questions which guided the study are used to summarize the data collected. Generalizations are made, based on the literature reviewed and data collected in the study. The findings of the study form the basis of some recommendations for further curriculum research.

The study is an examination of the interpretive process used by high school chemistry teachers in translating curriculum materials into classroom practice. The context of the study is high school chemistry, with the ALCHEM materials providing an example of a specific set of curriculum materials. The data collection and analysis in the study was guided by the following four questions:

1. What is the nature of teachers' functional paradigms as represented by the way they interpret curriculum materials?
2. What are some of the factors which influence teacher interpretation of curriculum materials?
3. What are some of the relationships among the these factors?
4. What would be some of the characteristics of a model of teacher interpretation of curriculum materials which is based on data derived from the study?

A. Summary of Data Collection and Analysis

The data for the current study were collected using both qualitative and quantitative approaches. Qualitative data were gained principally from observations and interviews with three selected chemistry teachers working in three different school settings. Each school site was visited five times over a period of four months. The quantitative methods included developing and administering a Student Opinion Survey (SOS) to the students of the three teachers who were observed and interviewed. In addition, the Chemistry Classroom Practice Survey (CCPS) was developed and administered to a randomly selected sample of Alberta chemistry teachers. The survey sample was drawn by randomly selecting 50 high schools from the 242 Alberta schools which offer a complete high school chemistry program. CCPS questionniares were sent to all the chemistry teachers in the schools selected and completed questionniares were returned by 69 teachers, working in 37 different schools. The school return rate was 74% and the estimated teacher return rate was 61%.

The interview transcripts and the responses to the open-ended questions in the CCPS were analyzed by categorizing the statements as they related to Schwab's four *curriculum commonplaces*: chemistry, teaching, students, and school setting. Recurring themes were then sought within each of these categories. The numerical data were entered directly into a computer file and were analyzed using standard programs from the Statistical Package for the Social Sciences (SPSS) library (Nie et al, 1975).

The demographic data collected by the CCPS questionniare indicate that Alberta chemistry teachers are predominantly middle-aged males. The estimated average age of the teachers in the sample is 39, with over two-thirds (67.6%) of the male teachers being over 35. The female teachers, who comprise only 17.6% of the sample, are somewhat younger and better trained than the males, and tend to be concentrated in the large urban senior high schools. Data from the questionnaire also indicate that Alberta chemistry teachers are highly experienced, with nearly three-quarters (72.0%) of the sample reporting a decade or more of teaching experience. A somewhat smaller proportion (52.9%) reported that much experience at teaching chemistry, suggesting that many teachers have moved into teaching chemistry recently, possibly as a result of shifts in teaching assignment which have accompanied declining enrollments in many schools. The demographic data captured by the CCPS questionnaire are consistent with the corresponding data collected in both the Science Council of Canada study (Orpwood & Alam, 1984) and the Canadian component of the SISS study (Connelly, Crocker, & Kass, 1984).

The data from the CCPS suggest some significant differences in the teaching situations of the rural and urban teachers who comprise nearly equal proportions of the sample. While urban teachers are required to teach larger numbers of students in a given semester, rural teachers are required to teach a greater variety of courses. Specialization in chemistry, both in terms of training and teaching assignment, is more frequent in urban than in rural schools.

B. Summary of Research Findings

The four research questions which guided the study will be used to structure the following summary of the research findings.

Question 1: Teachers' Functional Paradigms

The first research question was, "What is the nature of teachers' functional paradigms as represented by the way they interpret curriculum materials?" The data collected in the study suggest that there is some variation among the functional paradigms of chemistry teachers. The data indicate that each teacher's functional paradigm is made up of a somewhat different constellation of beliefs, values, techniques, exemplars, and routines, although many elements are shared among most teachers. Figure 2 contains a summary of some of the elements of teachers' functional paradigms which have been identified in the current study, with each value or belief associated with a particular way of using curriculum materials.

Figure 2 is based on an analysis of the interview transcripts and open-ended questions of the CCPS. The analysis of these data is based on the symbolic interactionist conceptions of *meaning* and *interpretation*. It is assumed that the meaning that curriculum materials have for a teacher can be inferred from what the teacher says about his use of the materials. It is also assumed that from these meanings valid inferences can be made about a teacher's beliefs and values and the influence they have on how he interprets curriculum materials. The role of symbolic interactionism in the study was primarily methodological, providing a conception of personal meaning which was amenable to empirical study. The symbolic interactionist view of personal meaning is highly individualistic and is not very useful in guiding a discussion of shared paradigms. For this reason symbolic interactionism is not used in the following discussion of the common elements in the functional paradigms of chemistry teachers.

To facilitate discussion of the data, Schwab's four curriculum commonplaces are used to organize Figure 2. This is not intended to imply that there are four distinct categories in the minds of teachers. On the contrary, data from the current study as well as from other related research (Crocker, 1979; Connelly & Elbaz, 1980; Connelly & Clandinin, 1982; Aikenhead, 1983; and Olson & Russell, 1984) suggest that the elements

Perception of High School Chemistry		Use of Curriculum Materials
-believe program limited to topics listed in curriculum guide	→	-limit selection of materials to topics in curriculum guide
-believe program includes a personal list of topics	→	-use elective time to cover specific non-core topics (e.g., gas laws)
-value major theoretical concepts and principles	→	-use elective time to stress theoretical topics (e.g., equilibrium)
-value applied chemistry	→	-use elective time to study applied chemistry topics (e.g., food chemistry)
-value nature of science	→	-use chemistry content to illustrate philosophy and process of science

Perception of Teaching		Use of Curriculum Materials
-value pedagogical efficiency	→	-select materials which can be marked and returned to students quickly
	→	-omit materials (e.g., labs, demos) which do not develop concepts quickly
	→	-rearrange topic sequences for more effective learning
-value academic rigor	→	-supplement with more detailed information
	→	-supplement with more challenging problems
-value motivating students	→	-stress lab work, demos, and novel presentations

Perception of Student		Use of Curriculum Materials
-focus on students' ability	→	-use extensively materials seen to be at students' level of ability
	→	-omit materials considered to be too easy or too difficult
-focus on students' interest	→	-select topics and activities that students enjoy (e.g., analytical chemistry)

Perception of School Setting		Use of Curriculum Materials
-focus on school facilities	→	-restrict lab work because equipment, materials, and assistance are unavailable
-believe expectations of community are an important consideration	→	-use materials that will aid student achievement
-believe needs of society are an important consideration	→	-stress connections among science, technology, and society

Some Elements in the Functional Paradigms of Chemistry Teachers and Their Influence on Interpretation of Curriculum Material
Figure 2

in teachers' functional paradigms are closely interwoven. In particular, it seems that teachers' values concerning the aims, purposes, and requirements of effective teaching are closely bound up in their perception of the other three commonplaces. In addition, the perceptions within each category are by no means mutually exclusive. In some cases two perceptions within a category represent the ends of a continuum with most teachers holding views somewhere between the extremes, as indicated by the range of responses to the items on the CCPS.

Perception of High School Chemistry: From data collected in the study, four related perceptions of high school chemistry were identified. One view is that high school chemistry is limited to the topics outlined in the curriculum guide. This perception of high school chemistry is associated with those teachers who limit their treatment of theoretical chemistry to the core program outlined in the curriculum guide, and use the time allotted for the elective component to study specific modules on applied chemistry.

Another view is that high school chemistry includes a more personal set of topics not listed in the curriculum guide. Although the specific topics in the set would be somewhat different for each teacher, for many teachers it seems to include equilibrium, reaction rates, gas laws, certain organic compounds (e.g., aldehydes, ketones, amines), and the quantum mechanical model of the atom. It seems that many teachers believe that these topics are essential components of high school chemistry, whether or not they are included in the core program outlined in the chemistry curriculum guide. This perception of high school chemistry is associated with teachers who use the elective component of the chemistry program to cover these topics. The data suggest that these topics come from previous high school chemistry programs that the teachers have taught (e.g., CHEM Study).

A third perception of chemistry emphasizes major theoretical concepts and principles and is associated with de-emphasis of applied chemistry in the curriculum materials and using the elective component of the chemistry program to study topics such as reaction kinetics, equilibrium, and solubility products. The data indicate that theoretical topics are often included in the personal list of topics valued by many teachers. Justification for emphasizing theoretical chemistry seems to come from the teachers' perception of what students will need to succeed in post-secondary chemistry courses. It may also be that teachers simply enjoy teaching these topics because they provide a convenient chemistry context for teaching mathematical problem solving (Olson & Russell, 1984).

A fourth perception of high school chemistry focuses on applied chemistry. This perception is associated with teachers who use applications of chemistry to develop chemical principles and who stress the connections among science, technology, and society (STS) in their chemistry classes. These teachers typically use the elective component of the chemistry program to study topics such as nuclear chemistry, analytical chemistry, food chemistry, metallurgy, and petroleum chemistry. A fifth perception of high school chemistry focuses on the nature of science, and is associated with teachers who use chemistry content to illustrate the process and philosophy of science. Teachers who emphasize the STS connection or the nature of science were a small minority of the survey sample as they were in the Science Council study (Orpwood & Alam, 1984).

Perception of Teaching: Data collected in the current study suggest three typical perceptions of teaching. One perception places a high value on pedagogical efficiency, that is, fast effective means of giving students a clear "understanding" of chemical concepts and principles. The interview data suggest that for many teachers student understanding is indicated by the student being able to correctly answer assigned or examination questions. This perception is associated with chemistry teachers who select materials on the basis of how quickly they can be completed, evaluated, and returned to the student. Worksheets of repetitive "type" problems (exemplars) are often chosen by teachers who value pedagogical efficiency, and much of the popularity of the ALCHEM materials seems to be due to these teachers. The valuing of pedagogical efficiency is likely reinforced by a sense of being rushed for time in completing the high school chemistry course, and seems to be strongest in situations where teachers are assigned several different courses and/or a large number of students to teach. This perception also leads to rearranging the sequence of materials, and omitting activities which are not regarded as contributing to an understanding of basic concepts in chemistry. Emphasis on pedagogical efficiency is associated with teachers who want curriculum materials to provide an abundant supply of student exercises.

Another view of teaching emphasizes academic rigor, which does not, in any way, preclude an appreciation of pedagogical efficiency. This perception is associated with teachers who regard the chemistry program and the prescribed materials as a "bare bones outline", and who supplement extensively with detailed background materials and challenging problems and activities aimed at developing students' intellectual abilities. Stressing academic rigor is associated with teachers who want curriculum materials to provide detailed background information on all the topics in the chemistry program. The emphasis on academic rigor seems to be connected with the view that high school chemisty is a select academic course intended for students who are university bound.

A third perception is that an essential component of effective teaching involves motivating students. Emphasis on lab work and use of entertaining, novel teaching approaches and spectacular demonstrations are some of the teaching techniques associated with this perception. This perception of teaching seems to be connected with the view that high school chemistry will be taken by students with a wide range of interests and abilities, not only those bound for post-secondary science programs.

Perception of Students: Two perceptions of students seemed to emerge from the current study, one focusing on students' abilities and another on students' interests. The focus on students' ability is associated with selecting curriculum materials on the basis of what is deemed appropriate for the the students' level of ability, while rejecting that which is judged to be too easy or too difficult. For example, some teachers omit the ALCHEM labs on molecular models because they are considered to be too simple for high school students, while others reject certain exercises on nomenclature because they involve too many different ions. The perception which focuses on student interests is associated with choosing topics and approaches that students will like. Several teachers mentioned student interest as the reason that they used the ALCHEM worksheets and lab activities, and as the reason that they selected elective topics such as analytical chemistry and nuclear chemistry.

Perception of School Setting: The "school setting" category was intended to include teachers' perceptions of the school in local community as well as in the larger society. While there were many references to the local community, there were very few to the larger social setting. Regarding the local setting, many teachers seem to focus on school facilites, typically citing lack of equipment, materials or lab assistance as the reason for not doing student experimental work. There was some reference to the expectations of the community in terms of achievement, leading teachers to select and use materials which will help students do well on examinations. Student achievement on examinations will likely be a more significant factor in teacher interpretation of curriculum materials since mandatory province-wide final examinations have been re-instated for all academic grade twelve subjects in Alberta. The only reference to the larger society was from one of the three teachers interviewed. He includes a discussion of the role of chemistry in society in his classes and provides a description of some of the careers to which a study of chemistry will lead.

Summary: The data collected in the study and summarized in Figure 2 indicates that teachers hold a range of beliefs and values about each of the four curriculum commonplaces. Overall, the data suggest that views of teaching and chemistry seem to dominate teachers interpretation of curriculum materials. In particular, a valuing of "the fundamental ideas of chemistry" and of helping students to become 'more cognitively competent" seem to be the strongest influences. Valuing the fundamental ideas of chemistry is associated with emphasizing theoretical chemistry, and developing cognitive competence is associated with valuing both academic rigor and pedagogical efficiency.

Question 2: Factors Influencing Interpretation of Curriculum Materials

The second research question was, "What are some of the factors which influence teacher interpretation of curriculum material?" Data from the current study suggest three sets of factors.

1. elements in the functional paradigms of teachers
2. teachers' background
3. teaching situation

Some of the beliefs and values which were identified as part of the functional paradigms of teachers were described in the previous section and their influence on interpretation of curriculum material was outlined. In addition, the observation and interview data suggest that certain techniques, exemplars, and routines are also part of the functional paradigms of teachers. Teachers' confidence in approaches that have worked well in the past seems to account for the development of idiosyncratic classroom routines to which curriculum materials are adapted. The range of frequency of use reported in the "Teaching Strategies" section of the CCPS suggests that the set of valued routines varies considerably from one teacher to another.

Of the factors related to the teachers' background, training in chemistry and experience in teaching chemistry seem to have the most influence on teacher interpretation of curriculum materials. The chemistry majors report developing their own supplementary notes and worksheets and using ALCHEM in conjunction with another text more often than do non-majors. Teachers with less experience teaching chemistry regard the ALCHEM student materials as more useful to them than do more experienced teachers. It seems that as teachers gain more training and experience, they become more self-sufficient and rely less on officially approved curriculum materials. Unfortunately, the CCPS question regarding the number of courses taken in science curriculum and instruction was misinterpreted by many of the respondents. As a result, it was not possible to investigate the influence that training in science education has on teacher interpretation of curriculum materials.

Of the factors relating to teaching situation, teaching assignment and school size seem to have the most influence on the way teachers interpret curriculum materials. The more students that teachers have, the more frequently they use tests, quizzes, films, and videotapes, and the more they value the worksheets, sample solutions, laboratory exercises, and demonstrations provided in the ALCHEM materials. These findings suggest that audiovisual materials and worksheets are teaching strategies that teachers use to cope with large numbers of students. Some teachers in rural schools indicate that they have difficulty doing laboratory work because of inadequate facilities. Teachers in smaller schools generally rate the ALCHEM worksheets, laboratory exercises, and demonstrations higher than teachers in larger schools, possibly because teachers in smaller schools have fewer other resources to draw upon.

Question 3: Relationships Among Factors

The third guiding question was, "What are some of relationships among the factors identified in question 2?" The data suggest that the factors coming from the teachers' background influence the formation of the teachers' functional paradigms. It was noted that chemistry majors rate the adequacy of their background for teaching high school chemistry, especially laboratory work, higher than did non-majors. Teachers who are specialists in physical science regard teaching students about the tentativeness of chemical theory as more important than teachers who are not specialists in physical science. Teachers with less experience regard students' background in science as more important than do more experienced teachers. The topics that teachers regard as appropriate for high school chemistry seem to depend on previous courses that they have taught. Apparently, a teacher's academic history, i.e., training in chemistry and experience in teaching chemistry, has a considerable influence on shaping his perceptions of the subject.

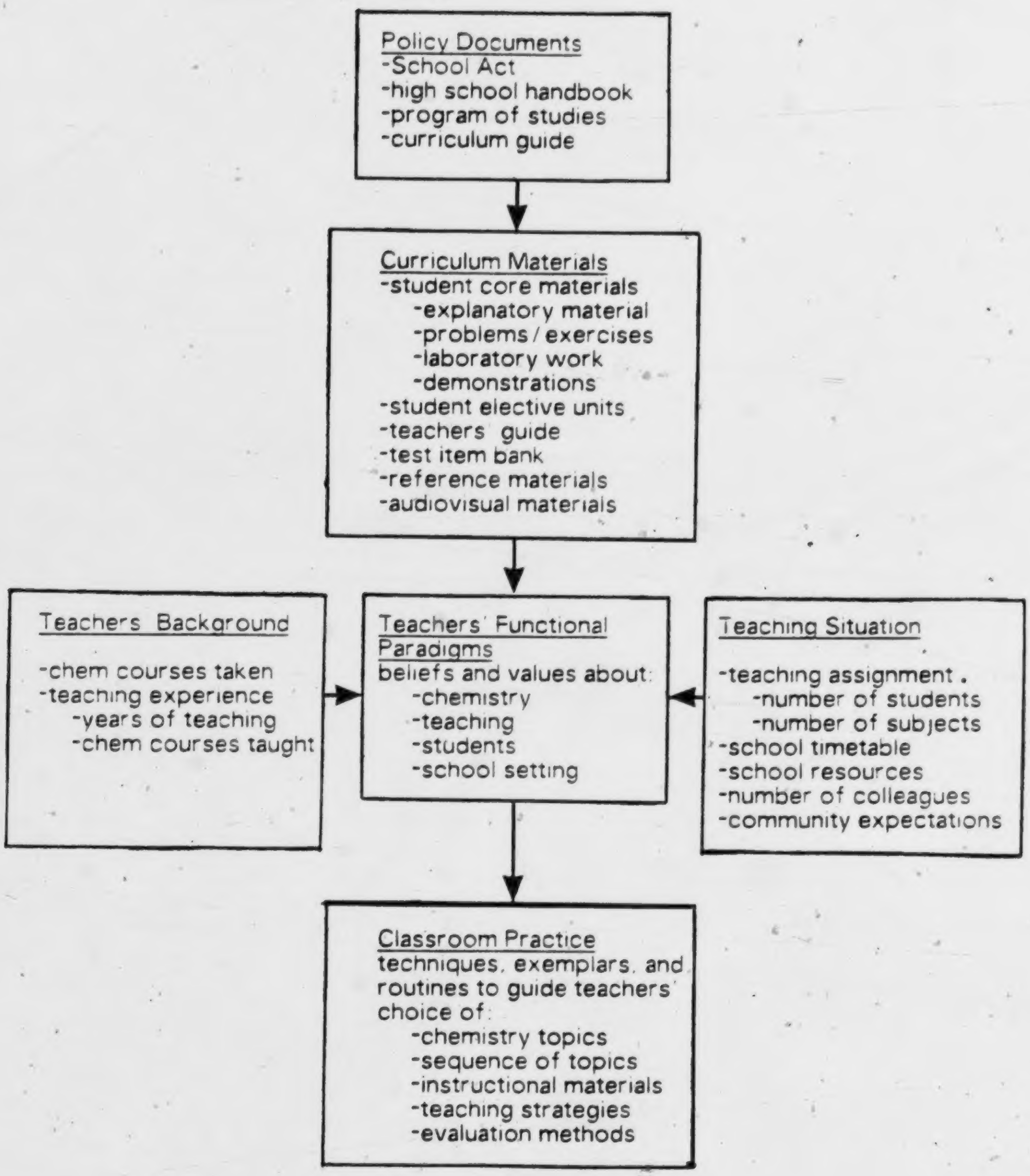
It is not suprising that teaching situation is a factor in interpretation of curriculum materials since teachers in different situations are provided with different sets of problems to address. Teachers in rural schools generally have more subjects to teach than urban teachers, while teachers in urban schools have more students to teach than rural teachers. The school facilities vary with the size of the school and the rural / urban setting. The data suggest that an important component of the teaching situation is the number of colleagues the teacher has and the availablity of laboratory aides to assist in preparing materials for student laboratory work. In addition, the data suggest that there is a consensus effect operating in larger schools, which tends to centralize curriculum decision-making and restrict the choices of the individual teachers. The study gives no suggestion about the dynamics of decision-making within a science department, but indicate that they are an important factor in the translation of curriculum materials into classroom practice.

Question 4: A Model of Teacher Interpretation of Curriculum Materials

The fourth guiding question was, "What would be some of the characteristics of a model of teacher interpretation which is based on data derived from the study?" Figure 3 is a schematic representation of a model of teacher interpretation of curriculum materials which is suggested by the findings of the current study. The model is intended to show that curriculum materials and the parameters for their use are authorized through a series of policy documents from the Ministry of Education. Curriculum materials are taken to include student materials for the core/elective program; teachers' guides, test item banks, as well as reference and audiovisual materials. The model indicates that curriculum materials are interpreted by a teacher's functional paradigm. The model suggests that the functional paradigm of a chemistry teacher includes certain beliefs about chemistry, teaching, students, and school setting; and certain values about the outcomes of chemistry education. Flowing from these values and beliefs are certain techniques, exemplars, and routines for achieving valued outcomes, which have become part of the teacher's classroom practice. The techniques, exemplars, and routines serve as a pattern which helps to guide a teacher's choice and sequence of topics, teaching strategies, and evaluation methods.

The model indicates that a teacher's background influences his interpretation of curriculum materials by shaping his functional paradigm. The number of university chemistry courses taken, the number of different high school chemistry courses taught, and overall teaching experience are identified as the salient aspects of a teacher's background.

Teaching situation influences interpretation of curriculum materials by establishing the parameters within which the teacher has to work. The number of students and the number of different subjects taught are identified as separate aspects of teaching assignment since they seem to influence interpretation of curriculum materials somewhat differently. The school's timetable refers to the length of the class period and semester/full year arrangements. The school's resources refers to lab aides, facilities, equipment, and materials. The number of teachers on staff and the expectations of the community are also identified as aspects of teaching situation which have a significant influence on curriculum materials.


Policy Documents
-School Act
-high school handbook
-program of studies
-curriculum guide
Curriculum Materials
-student core materials
-explanatory material
-problems / exercises
-laboratory work
-demonstrations
-student elective units
-teachers' guide
-test item bank
-reference materials
-audiovisual materials
Teachers' Background
-chem courses taken
-teaching experience
-years of teaching
-chem courses taught
Teachers' Functional Paradigms
beliefs and values about:
-chemistry
-teaching
-students
-school setting
Teaching Situation
-teaching assignment
-number of students
-number of subjects
-school timetable
-school resources
-number of colleagues
-community expectations
Classroom Practice
techniques, exemplars, and routines to guide teachers' choice of:
-chemistry topics
-sequence of topics
-instructional materials
-teaching strategies
-evaluation methods

Model of Teacher Interpretation of Curriculum Materials

Figure 3

Other models of how the intentions of curriculum developers are translated into classroom practice have been advanced (Roberts, 1980; Connelly, Crocker, & Kass, 1984). Roberts' model refers to a "developer-teacher interface" within which developers' intentions are communicated to teachers and teachers decide whether to reject or modulate the materials. In the model represented in Figure 3, teachers' functional paradigms serve as the interface which determines how curriculum materials will be translated into classroom practice. The model advanced by Connelly, Crocker, and Kass (1984) to represent the teacher as a curriculum translator, uses generalized components of the intended and translated curriculum. The model presented here focuses on teachers' interpretation of curriculum materials and identifies salient aspects of chemistry teachers' functional paradigms, background, and teaching situation from the data derived in the current study.

The model presented in Figure 3 is based on data collected from 72 different teachers. Consequently, the model represents an "averaged" picture of how a chemistry teacher interprets curriculum materials. The significance of different parts of the model will vary from one teacher to another. To illustrate how the model can be used to explain a teacher's interpretation of curriculum materials, it will be applied to each of the three chemistry teachers who were observed and interviewed in the study: Allan, Jensen, and Kurelek. The functional paradigms of the three teachers were described and compared in Chapter 4. The discussion here will focus on how the various parts of the model apply to each teacher.

Allan's idea of an adequate high school chemistry course seems to be a composite of all the previous chemistry courses he has taught, a view which is closely associated with the value he places on academic rigor in the form of the breadth and depth of his chemistry program. Through his years of experience Allan has developed teaching routines which are valued for their pedagogical efficiency, allowing him to cover the course material he considers necessary in the available time. It seems likely that if a new chemistry program were introduced, Allan would add it to the composite course he is already teaching, and would adapt the materials to fit his established routines. Allan is the only Chemistry 30 teacher in his school, which may account for why he is the least restrained of the three chemistry teachers in selecting and sequencing curriculum materials. The variety of courses that he is required to teach combined with the lack of a laboratory assistant makes Allan very conscious of the time required to prepare for student experimental work, and to mark laboratory reports and assignments. Consequently, he doesn't do very much lab work and opts for abbreviated lab reports and worksheets that can be marked quickly.

Although Jensen has been teaching high school chemistry for over fifteen years, he does not carry over content from previous chemistry courses into his present program. That he has dropped previous course materials and uses ALCHEM as his principal teaching resource may be due to his being involved as a pilot teacher in the development of the ALCHEM program. Through his years of teaching experience he has developed a number of teaching techniques which he uses routinely because he has found them an effective way of motivating students. In Jensen's case, the school provides excellent facilities in terms of lab equipment, materials, and support staff and Jensen is able to do as much student experimental work as time allows. Teaching in a large science department makes it possible to pool teacher developed materials, thus providing for an ample supply of supplementary worksheets. Being in a large science department also places some constraints on Jensen's curriculum decision making. It is the policy of the science department at Rutherford to have common final examinations for Chemistry 10, 20, and 30, and to study *Nuclear Chemistry* as one of the electives in Chemistry 30.

Teacher background seems to play a different role for Kurelek than for the other teachers, because he is not a chemistry major and has only one year of teaching experience. His university experience gave him the idea of using chemistry content to teach students about how scientific theories develop. University experience seems to be more significant for Kurelek than for the others, likely because it is more recent. As with Jensen, the laboratory facilities at Kurelek's school are excellent, and he is able to do as much student experimental work as he considers useful. As a beginning teacher in the Glenview's science department, Kurelek seems to be constrained to follow the curriculum decisions made by other teachers in the department regarding the sequence of topics, choice of electives, and use of common final examinations.

C. Major Findings

The following five points summarize the major findings concerning chemistry teachers' interpretations of curriculum materials. The implications of these findings for knowledge in the field of curriculum are discussed here with reference to the literature reviewed in Chapter 2.

1. The term *functional paradigm* seems a particularly apt way of describing the influence of teachers practical knowledge on interpretation of curriculum materials. Much as a research scientist is guided by a paradigm, classroom teachers seem to be guided in their interpretation of curriculum materials by certain beliefs, values, techniques, exemplars, and routines. Crocker (1983) has argued that the concept of a functional paradigm is a valuable construct for investigating *why* classroom teachers behave as they do. The findings of the current study support Crocker's argument, and suggest that the *functional paradigm* is as powerful a concept as *theories-in-use* (Argyris & Schon, 1974) for investigating how professionals are guided in their practice.

   One outcome of the study is a model of teacher interpretation of curriculum materials which uses the concept of a functional paradigm as a central construct. The model seems to be able to explain the interpretive patterns of the chemistry teachers in the study sample and the influences underlying these patterns. The functional paradigm concept promises to be a valuable construct for investigating translation of curriculum materials in other subject area and other aspects of teachers' decision-making as well. In this way the model presented here may contribute to a further understanding of teachers' practical knowledge (Connelly & Ben-Peretz, 1980; Connelly & Elbaz, 1980; Clandinin, 1983).

   In advancing the functional paradigm concept Crocker (1983) contended that research on teaching would benefit from a shift in focus from the differences between teachers to the commonalities among them. The findings of the current study indicate strong common themes in the ways that chemistry teachers interpret curriculum materials. The current study also indicates that there are some significant differences among chemistry teachers in the way that they interpret curriculum materials. The functional paradigm concept accounts for the differences by allowing for variations in the individual elements within the functional paradigm. That is, different teachers have a somewhat different constellation of beliefs, values, techniques, exemplars, and routines. The results of the current study indicate that, overall, the commonalities among teachers are much greater than the differences.

2. The study found that teachers place a high value on teaching theoretical chemistry and a low value on teaching the STS connection and the nature of science. This finding is consistent with other recent studies of Canadian science teachers (Brauer, 1981; Orpwood & Alam, 1984) and has implications for the current movement in chemistry education toward producing curriculum materials which emphasize these two aspects of chemistry (Fensham, 1981; Nelson, 1983; Webb, Last, & Rayner-Canham, 1983). If teachers do not value teaching students about the nature of science and its social context, these aspects of the materials will not likely be translated into classroom practice (Roberts, 1980; Fullan, 1982). It must be recognized that implementation of new courses of study, with their attendant curriculum materials, often involve major "paradigm shifts" for classroom teachers (Crocker, 1983). Implementation of new programs, such as those recommended in the Science Council of Canada's Report 36 (Science Council, 1984), will need to devote adequate attention to the implementation phase if any positive change in the schools is going to be brought about by the proposed programs (Leithwood, 1981). The curriculum research literature (Gallager, 1966; Herron, 1971; Welch, 1979; Werner, 1980; Fullan, 1982) and data from the current study indicate that conventional inservice programs are not sufficient to inform teachers of the intentions of curriculum innovations or to provide them with the additional background that new programs typically require.

3. The data from the current study indicate that teaching concerns are paramount considerations of teachers when they translate curriculum materials into classroom practice. Chemistry teachers have developed teaching techniques and classroom routines stressing pedagogical efficiency, academic rigor, and motivation of students to which they adapt curriculum materials. Curriculum developers and school authorities should regard teachers' functional paradigms as resources to be tapped rather than obstacles to be overcome (Connelly & Ben-Peretz, 1980). It

should be recognized that teachers' functional paradigms are very much attuned to the realities of contemporary classroom life and could provide valuable information concerning the most appropriate content and format for curriculum materials. By providing a feedback mechanism for teachers, developers would have access to a source of information which could guide their revisions of the material so that the original intentions of the materials could be more effectively accomplished in the classroom setting (Roberts, 1980).

4. The data indicate that the academic history of teachers seems to play a large part in shaping their functional paradigms. Training in chemistry and experience in teaching different chemistry programs are identified as factors which have a particularly strong influence on teacher interpretation of curriculum materials. A detailed examination of how academic history shapes the functional paradigms of teachers would seem to be an important area of investigation.
5. The data also indicate that a teaching situation has a significant effect on how curriculum materials are interpreted. In particular, the teaching assignment (including both number of students and number of different subject taught), number of colleagues, and school resources seem to be significant factors. These findings raise questions about how teachers develop strategies for coping with their teaching assignment given their school's resources, and what the dynamics of curricular decision-making in a science department might be.

D. Recommendations for Further Research

The current investigation is an attempt to contribute to a better understanding of the essential link between the intentions of curriculum developers and the actual use of the materials in the classroom. The current study was directed toward developing a theoretical basis of viewing implementation which would be useful to both curriculum practitioners and researchers. The study suggests some areas of further research which would contribute to understanding the process of translating the intended curriculum into classroom practice.

1. Studies could be undertaken to investigate whether any of the findings of the current study are generalizable to other science curricula. The same basic methodology

used in the current study could be improved to increase confidence in the findings. For the observation and interview phase of the research, a larger number of teachers would provide a richer data base for investigating the functional paradigms of science teachers. Drawing a larger sample for the survey phase of the study would reduce the sampling error and increase the probability of detecting any significant differences that might exist among the interpretive patterns of different groups of teachers. By clarifying the wording of questions relating to science education, the influence of this factor on teachers' interpretation of curriculum materials could be examined. The influence of mandatory external examinations on teacher interpretation of curriculum materials could be explored by adding appropriate questions to both the interview and survey phases of the study.

2. Studies could be undertaken to investigate the role of training and experience in forming teachers' functional paradigms. Longitudinal studies could be undertaken, beginning with students at university (prior to their first curriculum and instruction course and practicum experience) and continuing through several years of teaching. The study could also examine the effect on the functional paradigms of teachers of moving from one subject area to another (e.g., biology to chemistry) after a few years of teaching experience. Observation and interview methods, as well as requiring the participants to keep a log book, would seem to be appropriate techniques for these studies.
3. An ethnographic study would seem to be an appropriate approach for investigating the dynamics of curriculum decision making within a high school science department. The study could examine how one teacher influences another and to what extent the science teachers in a department act under a shared paradigm for curriculum decision-making. In addition, such a study could investigate how teachers develop teaching strategies and classroom routines for coping with their teaching assignment and the parameters imposed by their particular teaching situation.

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APPENDIX A

The following information is taken from the document, *Curriculum guide for senior high school chemistry* (Alberta Education, 1977).

A. Objectives of Secondary School Science for Alberta

The learning of science as an area of human endeavour, should provide the student with a scientific literacy which enables him to assume an active and useful role as a citizen in a democratic society. It may be assumed that this literacy is best achieved by considering the individual needs of students and through independent study and learning.

The objectives of Secondary School Science are:

1. To promote an understanding of the role that science has had in the development of societies
    a. history and philosophy of science as part of human history and philosophy
    b. interaction of science and technology
    c. effect of science on health, population growth and distribution, development of resources, communication and transportation, etc.
2. To promote an awareness of the humanistic implications of science:
    a. moral and ethical problems in the use and misuse of science
    b. science for leisure-time activities.
3. To develop a critical understanding of those current social problems which have a significant component in terms of their cause and/or their solution:
    a. depletion of natural resources
    b. pollution of water and air
    c. overpopulation
    d. improper use of chemicals
    e. science for the consumer
4. To promote understanding of and development of skill in the methods used by scientists:
    a. processes in scientific inquiry such as observing, hypothesizing, classifying, experimenting and interpreting data
    b. intellectual abilities such as intuition, rational thinking, creativity, and critical thinking

   c. skills such as manipulation of materials, communication, solving problems in groups, and leadership.

5. To promote assimilation of scientific knowledge:
   a. emphasis on fundamental ideas
   b. relevance of scientific knowledge through inclusion of practical applications
   c. application of mathematics in science
   d. interrelationships between the sciences
   e. open-endedness of science and the tentativeness of scientific knowledge.
6. To develop attitudes, interests, values, appreciations, and adjustments similar to those exhibited by scientists at work.
7. To contribute to the development of vocational knowledge and skill:
   a. science as a vocation
   b. science as background to technical, professional and other vocations.

B. Objectives of High School Chemistry

In pursuit of scientific literacy, students in a chemistry program should strive to achieve the following objectives:

1. Develop skill in the methods used by chemists such as:
   1.1 processes in scientific inquiry: observing, hypothesizing, classifying, experimenting, and interpreting data.
   1.2 skills in the cognitive, affective, and psycho-motor domains.
   1.3 skills in individual and group problem solving.
2. Acquire a working knowledge of:
   2.1 the fundamental ideas in chemistry
   2.2 the applications of the fundamental ideas
   2.3 the interrelationships among the different sciences and mathematics
   2.4 the tentativeness of chemical theory
3. Acquire a background knowledge about such issues as:
   3.1 use and depletion of natural resources
   3.2 chemistry of environmental pollution
   3.3 use and misuse of chemicals such as preservatives, additives, insecticides, etc.

4. Acquire a background knowledge and experiences in the application of chemistry such as:
    4.1 chemistry in the home
    4.2 leisure-time activities such as photography, automotives, etc.
    4.3 consumer chemistry
    4.4 chemistry in industry
5. Develop an awareness and critical understanding for decision-making on value issues arising out of the use and misuse of chemistry.
6. Acquire a knowledge and appreciation of the history and philosophy of chemistry.
7. Develop a background of chemical knowledge and skills prerequisite to future careers.

C. Introduction

If Chemistry is considered to be a basic science integrating much of man's understanding of nature it seems reasonable to provide a program which is suitable for and which appeals to, a significant portion of the high school population.

To this end the committee has attempted to develop a program which will meet, in a balanced way, the objectives of Secondary School Sciences as published in the Program of Studies for Secondary Schools. We would hope that this program would present Chemistry as a lively, interesting and important part of the scientific adventure which involves, in one way or another, the whole spectrum of society. We seek to show that Chemistry has developed in a very human way with a history of frustration, enlightenment, revision and practical application. Not only have these been aspects of past development but they are very evident in the Chemistry of the present.

As a result of this approach to teaching Chemistry the Committee would hope that the courses would be appealing to a wider segment of the student population than is the case at present. To further this end and also to make the courses more responsive to changing emphases, interests and available materials, we have sought to introduce a certain amount of flexibility into the program. The Committee also feels that this program would continue to apply the process skills emphasized strongly in the Elementary and Junior High Schools.

D. Chemistry Program

Program Objectives: Students should develop

1. Scientific process skills.
2. A knowledge of chemistry as a field of study.
3. The ability to analyze current problems and issues.
4. The ability to apply skills and knowledge to real situations.
5. An understanding of the historical antecedents and apply these understandings to current issues.
6. A knowledge of the roles of different individuals in chemical related vocations.

E. Program Outline

Chemistry 10

CORE

About 40 hours

1. Basic skills of scientific experimentation.
2. Theoretical bases.
3. Language of Chemistry.

ELECTIVES

(1 or more to be chosen) About 25 hours

Metallurgy
Chemicals in the environment
Chemicals in the marketplace
Chemistry of Photography
Locally developed unit

Chemistry 20

CORE

About 40 hours

4. Solutions.
5. Bonding.
6. Organic Chemistry.

ELECTIVES

(1 or more to be chosen) About 25 hours

Polymers
Biochemistry
Environmental Chemistry I
Qualitative Analysis
Chemistry of the Car
Locally developed unit

Chemistry 30

CORE
About 75 hours

7. Chemical Change.
8. Proton Chemistry.
9. Redox Reactions.

ELECTIVES
(2 or more to be chosen) About 45 hours

Rate of chemical reactions
Chemical equilibrium
Radiation chemistry
Organic chemistry
Environmental problems
Industrial chemistry and people
Food chemistry
Fossil fuels as energy or feedstock
Locally developed unit

F. The Teaching of Chemistry

Teaching Procedures

Teachers should familiarize themselves with the objectives to be achieved by the students who study this chemistry program. The particular teaching strategies or approaches to be used by the teacher should be those which will give students a variety of learning experiences focussing on achievement of the objectives. At the same time, a balance must be maintained between theory and application and between inductive and deductive thought processes.

The program is intended to appeal to a wide segment of the student population. However, this should not be misinterpreted to mean that serious study and diligent work on the part of the student is no longer required. Standards can and should be maintained. It is felt that there are a significant number of capable students who are not, for one reason or another, taking chemistry and that they could benefit from doing so.

Concept Formation

It is important for the teacher to remember that concept development is an ongoing process. Generally, it begins for the student as a result of a particular learning "incident". Development comes from a variety of additional learning experiences. The teacher obviously has a most important role in planning for, organizing and presenting these experiences for students but it is the student who must "do the learning".

A highly diversified program emphasizing direct physical experiences reinforced by the use of print and non-print materials and discussion is essential to the development of most concepts. Only then, will early learning form a base for the assimilation of experiences that come later—experiences that may involve either direct observation (using all the senses) or verbal and pictorial reports of observations made by others.

Use of Textbooks

All too often a textbook has been accepted in many classrooms as the program of studies. Experience has shown that the use of a single text has been inadequate when teachers attempt to meet the range of individual abilities. One must consider both the strengths and limitations of a textbook and exercise discretion in its use. The use of a variety of texts helps to provide alternate methods and approaches to accommodate ranges of performance and interest. No text, manual, or single aid will provide a creative and appealing approach to instruction for everyone. Students differ and communities are varied, so that the creative ability and background of students demand variation in instructional patterns.

The Role of the Laboratory in Chemistry

The challenge of chemistry teaching is to involve the student to the maximum extent possible with the concepts of chemistry. How does one meet this challenge? What activities does one use? How and when should students be involved? What hazards are involved? These and other questions confront every chemistry teacher. The answers that others have found vary according to the goals sought and the personal experience and background of the teacher. There are however, some common elements in the various solutions.

To participate actively in the search for knowledge, the student must have certain skills with respect to the acquisition and the utilization of data. Data collecting in and of itself will serve no useful function. Knowing what data to collect is far more important, but the student cannot know what data to collect until he has gained the skill of proposing the questions that are to be answered. The questions in turn, cannot be proposed until the student is able to evaluate the various components of the environment and critically analyze them in terms of what information will be needed to answer the questions. Having collected the data, the student must then interpret it in an acceptable manner and evaluate it with respect to the methods used in its collection before he can accept or reject his initial solution to the problem.

The laboratory must function to provide the student with the required skills for the generation of knowledge. These skills are vital to the student because of new problems he will be asked to answer and areas of knowledge that will come into existence during his lifetime. It will also provide answers to traditional problems that have been accepted as worthy of answering. The acquisition of knowledge-generation skills must stand as the foremost objective of the laboratory portion of the high school chemistry course.

The new programs utilizing the inquiry approach have developed extensive materials that will assist the teacher in reaching the stated objectives with respect to the laboratory work. These procedures will not be repeated here. Instead, teachers are urged to examine each program's material and apply it as it fits their individual situations.

The high school chemistry course has traditionally been segmented into a lecture portion and a laboratory portion. The lecture has been used primarily to disseminate information. Students have been expected to take notes on the material "covered" in class and to reproduce that material on tests. Very little opportunity has been given for the frank and open discussion of problems which require knowledge of chemistry and research skills to arrive at viable solutions.

The laboratory portion of the course was initially designed to provide "experiences" whereby the student could come to understand what the research chemist does. Typically, the student starts with a complete set of instructions that inform him of the exact procedures he will use and observations he will make during the laboratory period. He is then provided with questions that require him to fill in the appropriate word in the blank. It is unfortunate that the world does not provide such a convenient format for the research chemist or the scientist!

The function of dispensing information by the teacher is being replaced. The teacher is becoming a designer of environmental encounters. Some psychologists contend that a student does not truly acquire information that is structured in his mind until he has had the opportunity to act physically upon it. It would follow then, that the more energy the student expends in gathering and processing information the greater would be the probability that it would be incorporated into his cognitive framework in some meaningful fashion. Thus, it should be the role of the teacher to provide as many opportunities as possible for the student to become involved in collecting and organizing information. Students can read faster than the average teacher can speak. It would seem to be advantageous to assign reading that provides the best presentation of the background material the student will need to act on a given problem situation.

Having assigned the information-dispensing responsibility to textbooks or carrel experiences, the teacher must now decide what adequately written objectives will be accomplished in the remaining time. Since science is a problem-solving activity, the time could be spent introducing the students to problem-solving procedures. Problems for consideration may be presented by demonstrations, films or filmloops, or by laboratory activities in which the student defines the problem to be studied and decides on a method for studying that problem.

The amount of time devoted to the laboratory portion of the course will depend on: (a) the syllabus for the course, (b) other teachers giving the same course, (c) the departmental chairman, or (d) the teacher himself. In lieu of other guidelines, it is a common practice to devote approximately 40 percent of the class time to laboratory activities. This may be distributed on a fixed, twice a week schedule, or it may be varied to fit the sequence of instruction.

Laboratory Safety

The prevention of accidents in a laboratory is the responsibility of every individual who enters it. For the teacher, there is a special responsibility to reduce the potential incident that could give rise to injury. In this context laboratory safety is to be a positive component of science teaching and the teacher should stress the importance of careful planning. The result of this part of the chemistry program should be students with safety-conscious attitudes and behaviors. Since students tend to lack the instinctive feeling for investigative work that comes from long-term familiarity with the laboratory, they must be taught how to handle materials which are potentially harmful to them.

The laboratory environment should not be hostile to the student and should be equipped with the appropriate safety devices and materials. For example:

1. If a heating device is to be used then an appropriate fire extinguisher (either CO_2 or dry powder) should be available, or a suitable alternative of a sand bucket, fire blanket, sprinkler or shower bath should be at hand.
2. If corrosive reagents are to be used then a suitable first aid kit and washing facility should be at hand.
3. All flammable or toxic vapor producing reagents should only be used where venting is available and suitable precautions are observed by all participants.

The possibility of accidents and the potential hostility of the chemical laboratory can be reduced by:

1. Storing all corrosive chemicals and flammable solvents as close to the floor as possible in a suitably lined cupboard or cabinet.
2. Not storing reagents which may react violently with each other in close proximity.
3. Storing sodium and potassium under kerosene.
4. Not storing excessively dangerous substances such as white phosphorus, perchloric acid, benzoyl peroxide.

5. Ordering quantities of chemicals and reagents that can be reasonably consumed in the next year. There is some false-economy in storing chemicals over several years if their quality, efficacy or potency changes with time.
6. Storing all chemicals in a secure, well ventilated room in containers that are clearly labelled.

There are many other specific "do's" and "don'ts" related to specific situations and activities. For further guidance, teachers are referred to their school or school jurisdiction's policy or safety handbook. For additional information teachers are also referred to Everett, K. and E. W. Jenkins *A Safety Handbook for Science Teachers, New Edition*. Don Mills: Longman Canada Limited, 1976.

As a closing note, school science laboratories can be as safe a place to teach and learn as any location in the school. This will only be the case through the constant vigilance of teachers and students alike.

G. The Curriculum Structure

1. This program is developed on a core-elective method of curriculum organization. Briefly this means that a core occupying fifty to sixty percent of the time allotment will be prescribed for all schools in Alberta. An elective portion of approximatelly forty to fifty percent of the time will be allowed for modules which take advantage of local interest, expertise, and facilities. It is felt that this approach allows for a number of advantages.
   a. It provides for both flexibility and uniformity.
   b. Because the core would contain those parts of the course which are relatively constant and the elective modules would contain those parts of current interest, this system of organization would allow for up-dating on a continuous basis.
   c. Local interests, facilities, and expertise can be brought into the chemistry program very easily.
   d. Modules which involve more than one discipline could be developed. There is a concern that science has become too specialized and modules of this type

would counteract this impression.

e. This approach is somewhat adaptable to individualization.

f. This approach also can adapt quite easily to a variety of teaching materials.

2. The basic structure of the chemistry program is a core set of concepts running through the three years of Chemistry 10, 20 and 30, and a minimum of 4 elective modules.

It is the intention that these elective modules accommodate and augment class preferences, individual differences and teacher specialties. In general, the elective modules are to be of about 1 credit's worth of time, although there is no intention to be restrictive in format or in time allotments as long as the objectives are being addressed and met. The intent of this portion of the program is to provide some limited opportunities for modification of the program to suit local needs and at the same time provide a measure of consistency across the province.

3. Some points to keep in mind when using the core-elective program.

a. Care must be taken to ensure that a balanced treatment of the elective objectives is achieved. It is easy to usurp some of the time allotted to elective modules to cover the "more important" core material. The philosophy of the core-elective approach dictates that this be scrupulously avoided.

b. Another underlying advantage of the core-elective approach is its adaptability to change. Those aspects of the program which are most susceptible to change can be placed in the elective part while the more stable aspects can be kept in the core. Care then must be taken to ensure that suitable material is placed in each of these two parts.

c. The elective nature of the program does not imply lack of structure. Structure in the form of objectives and content should be there but not to the detriment of the intent of the program. If opportunity to enhance the program presents itself but requires changing of the organization of the modules the freedom exists to change it. Whether change "in mid-stream" should be made in a module is up to the professional judgment of the teacher.

d. Another underlying advantage is that this kind of curriculum is not dependent on one set of materials but can be taught using a variety of materials available. In fact it can best be taught if there is a variety of materials available.

H. Elective Modules

In choosing modular units the examination of the objectives is of primary importance. In considering the objectives of the modules a number of factors should be considered:

1. Balance of theory vs. practical application and a balance in the teaching activities to match the learning styles of the students.
2. Interests of the students.
3. Interests of the teacher.
4. Expertise of the teacher.
5. Facilities and resource materials available.

Objectives should be examined with a view to determining how best to evaluate when these objectives have been achieved. Further care should be taken to ensure that a particular module is compatible with the overall chemistry program.

The above statements should not be misconstrued to give the impression that a great deal of structure is required. The purpose of the module structure is to provide flexibility in the approach to local needs. This should remain upper-most in deciding what is to be covered in the elective portion of the course.

The interdisciplinary possibilities of modules should be actively considered. This is a chance to integrate the various topics of Chemistry as well as to integrate chemistry with other areas of learning, such as Mathematics, English, Social Studies, etc.

I. Chemistry 10

Objectives of the Chemistry 10 Program

After participating in the activities and completing the requirements of this course, the student should

10.1 Know those concepts of chemistry as specified in the core outline.

10.2 Have competence in the language of chemistry: naming and writing the formulas and chemical equations.

10.3 Be skilled in techniques used by investigators in the field of chemistry.

10.4 Have a background knowledge related to the importance of chemicals and chemical processes in our economy.

10.5 Be aware of the possible harm to the environment which may arise from heavy metals.

10.6 Know the contributions made by various scientific investigators to the topics being studied.

10.7 Be aware of chemistry as a possible vocation and have an appreciation of its association with other sciences.

Organization of Program

Approximately 40 hours of instructional time shall be devoted to the core topics and about 25 hours to elective topics. The content of the elective units is to relate to the core in one of three ways:

a. an extensive study of a core topic
b. an in-depth, intensive study of a core topic, or
c. a practical application of a core topic

J. Chemistry 20

Objectives of the Chemistry 20 Program

After participating in the activities and completing the requirements of this course, the student should:

20.1 Know the chemical principles underlying the chemistry specified in the core outline.

20.2 Be skilled in using proper laboratory techniques used by chemists and laboratory personnel.

20.3 Comprehend the historical development of the chemistry principles being studied.

20.4 Have the capacity to apply the knowledge and skills of chemistry to other situations involving chemicals at home and in industry.

20.5 Have interests and attitudes toward chemistry that will assist in the choice of vocations.

20.6 Know the chemistry facts and principles related to the open discussion of social issues of current interest.

Organization of Program

Approximately 40 hours of instructional time shall be devoted to the core topics and about 25 hours to elective topics. The content of the elective units is to relate to the core in one of three ways:

a. an extensive study of a core topic
b. an in-depth, intensive study of a core topic, or
c. a practical application of a core topic

K. Chemistry 30

Objectives of the Chemistry 30 Program

After participating in the activities and completing the requirements of this course, the student should:

30.1 Know the facts and principles of chemistry as specified by the core outline.
30.2 Have competence in using the processes and techniques of chemistry in the identification of problems and the testing of proposed answers.
30.3 Be aware of the chemical factors related to issues of current interest.
30.4 Be informed about vocational and career opportunities in the chemical and technical fields.
30.5 Know the contributions that various investigators have made in the development of current chemical theories.
30.6 Understand the application of the concepts and principles learned in class to the production and use of such products as ethylene, gasoline, plastics, fertilizers, pesticides and foods.

Organization of Program

Approximately 75 hours of instructional time shall be devoted to the core topics and about 45 hours to elective topics. The content of the elective units is to relate to the core in one of three ways:

a. an extensive study of a core topic

b. an in-depth, intensive study of a core topic, or

c. a practical application of a core topic

APPENDIX B

The following information is taken from the preface to the ALCHEM worktexts (Jenkins et al. 1976).

A. Introduction

ALCHEM is the result of many educators joining together to write and teach a chemistry program that would meet the needs of today's students. Through six years of classroom experimentation with over 50,000 students, the program has come to its present form. In answer to the request made by teachers and students throughout the country, ALCHEM has become the most descriptive and applied chemistry material available on the market today.

This approach of applied and descriptive chemistry is integrated into the textual material, labs, demonstrations and classroom exercise to an extent never done before. Environmental, consumer and industrial chemistry are found throughout the program as well as many historical references and biographies on famous chemists. All this has been achieved without sacrificing a high level of chemistry. The chemistry content is not watered down. You will see from the unique design of the format, that the material has an easy-to-learn-from classroom approach. Students like using the program and their achievement level is high. Test results prove that ALCHEM students have significantly outperformed students on other programs and they have shown an equal or higher interest in chemistry.

B. Organization of the Program

In its present form there are three core books, ALCHEM 10, ALCHEM 20 and ALCHEM 30, which can be used for two half-courses and one full course, respectively, or with two full courses. Each core book is divided into units that cover specific topics. Within each unit, labs, demos and exercises are integrated in a logical sequence with the textual material. The ALCHEM 20 and 30 each have a complete review unit that acts as a refresher for the student who may not be familiar with previous content. It is our experience that a student can begin the program quite easily even if he or she starts with ALCHEM 30. Each core book can stand on its own.

In addition to the three core books, seven elective units are available to give added dimension to special topics selected by students or teachers. The core units emphasize the concepts of chemistry and bring in the applied and descriptive chemistry where possible. The elective units emphasize the applied and descriptive chemistry and bring in the concepts of chemistry where possible. There is a balance of organic and inorganic electives. The elective units are; *Foods and Their Analogs, Athabasca Tar Sands, Analytical Chemistry, Nuclear Chemistry, Metallurgy and Corrosion, Ethylene and its Derivatives,* and *Alberta Chemical Industries.*

The strongest feature in the whole program is that all the material has been reworked and revised many times to make it pedagogically sound for both the student and the teacher. Many new ways of approaching traditionally difficult chemistry concepts have resulted in the student finding the new approaches easy to understand. For example, the *Gravimetric Stoichiometry* unit is prepared for so thoroughly in the earlier units that it becomes a summary unit. Seven types of bonding in the *Chemical Bonding* unit are explained simply in terms of simultaneous attractions. All questions in the *Energy* unit are done by the approach of heat lost equals heat gained. All redox and acid-base reactions are done by a single five step method.

Another strong feature is the format. In many respects the teacher preparation time has been redirected. The students have the complete program in front of them in their loose leaf binders. Prepared exercises for the student to complete are placed next to the topic covered. Here the organization of the material minimizes the students confusion found in the use of other textbooks. The format of the exercises makes it easier for the teachers to concentrate on classroom strategies. Because quality classroom activities are already developed in the core material and the electives, the teacher has more time to devote to class and individual questions, implementing a wider variety of teaching strategies, spending more professional time on test making and reading, and preparing elective materials.

In addition to the above mentioned texts, an ALCHEM periodic table is available within each core book. Periodic table wall charts will also be available. ALCHEM 30 has an ALCHEM data sheet. Test item banks are available for ALCHEM 10, 20 and 30.

C. Special Features

The ALCHEM material was developed by the authors in consultation with science curriculum advisors in both education and chemistry at the University of Alberta. Through the years of pilotting, many of the authors and pilot teachers devoted much of their free time and expertise to the improvement and enjoyment of their profession by producing a better chemistry program. ALCHEM serves as a model to what can be accomplished through local curriculum development projects. It also shows what dedicated classroom teachers can do, for without them, we would not have this classroom oriented approach. The over 120 pilot teachers that worked with the program, contributed feedback that is not normally found in other textbook projects. Their comments and criticisms helped make the material work better in the classroom.

For those concerned about the rising costs of textbooks, the ALCHEM prices are very reasonable. In fact, the ALCHEM program costs less than the conventional textbook program even if you amortize the costs of the conventional text over a three to five year period.

The illustrations are of a comic nature to add some fun and enjoyment to the serious chemistry topics. They are designed to bring humor into the classroom—to let the student feel that chemistry does not have to be a heavy subject.

The United States National Institution of Education Curriculum Development Task Force has found that a major reason for the failure of million dollar curriculum projects in the past, has been the lack of significant participation by classroom teachers. ALCHEM is successful because classroom teachers created the program and students find it to be an enjoyable and rewarding learning experience.

The Symons Report has stated that, "A curriculum in this country that does not help Canadians in some way to understand the physical and social environment in which they live and work . . . cannot be justified in either academic or practical terms. It is essential, from the standpoint of both sound balanced scholarship and of practicality, that studies of the Canadian situation occupy an appropriate place in the curriculum . . .". ALCHEM is an example of a program that fulfills many of the recommendations made in the Symons Report. ALCHEM is truly a Canadian science program.

The major recommendation of the International Conference on New Directions in Chemistry Curriculum held in 1978 at McMaster University stated that a greater portion of applied and descriptive chemistry can be integrated into chemistry core and elective curriculums and textbooks. In order to accomplish this addition some of the most theoretical topics have to be cut. ALCHEM serves as a unique example of how the applied and descriptive chemistry can be integrated into curriculum materials.

D. Authors

Frank Jenkins	ALCHEM Director Queen Elizabeth Composite High School
George Klimiuk	Harry Ainlay Composite High School
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Dale Jackson	Victoria Composite High School
Tom Mowat	Ross Sheppard Composite High School
Myron Baziuk	Louis St. Laurent Separate School

E. ALCHEM 10

Unit A: Elements and the Periodic Table (A1-A40)

Topics: Objectives, Lab A1 - Safety and Efficiency in the Laboratory **A1** Part 1: The Classification of Elements into a Periodic Table on the Basis of Chemical and Physical Properties **A3** Classification Systems - a Preview **A4** Atomic Symbols **A5** Classification and Properties of the Elements **A13** Lab A2 - Properties and Applications of Elements **A21** Part 2: A Theory of Atomic Structure **A27** Models of the Atom **A28** Modified Bohr Model of Atoms and Simple Ions (Energy Level Diagrams) **A32** Overview **A35** Definitions **A37** Optional Exercises **A38** **Biography**: Dmitri Mendeleev (1834-1907) - The History of the Periodic Table **A10**

Unit B: Compounds, Bonding and Nomenclature (B1-B32)

Topics: Objectives, Classification of Compounds **B1** Chemical Bonds **B2** Covalent Bonding in Molecular Substances **B3** Nomenclature of Molecular Substances **B4** Lab B1 - Molecular Models **B6** Ionic Bonding in Ionic Compounds **B8** Nomenclature of Ionic Compounds **B9** Hydrated Compounds **B15** Lab B2 - Properties of Ionic and Molecular Substances **B18** Hydrogen Compounds and Acids **B22** Nomenclature of Binary and Oxo Acids **B23** Overview **B26** Definitions **B27** Optional Exercises **B28 A History of Chemical Nomenclature:** Antoine Laurent Lavoisier (1743-1794) **B16** John Dalton (1766-1844) **B16** John Jacob Berzelius (1779-1848) **B17** Alfred Stock (1876-1946) **B17**

Unit C: Chemical Reactions (C1-C34)

Topics: Objectives, Lab C1 - Evidence for Chemical Reactions **C1** Balancing Chemical Equations **C5** Lab C2 - Balancing Equations (Molecular Models) **C6** Demo C1 - Types of Chemical Reactions **C9** Classifying Reactions and Balancing Chemical Equations **C9** The Mole and the Balanced Equation **C15** Lab C3 - Chemical Reactions (An Overview **C19** Writing Chemical Equations and Predicting Products for Simple Composition, Simple Decomposition, Single Replacement, Double Replacement and Hydrocarbon Combustion Reactions **C16-C27** Overview **C28** Definitions **C34** Optional Exercises **C30**

Unit D: The Mole (D1-D22)

Topics: Objectives, International System of Units - SI **D1** Significant Digits **D3** The Mole **D7** Moles of Atoms **D9** Molar Mass **D10** Lab D1 - The Operation of a Balance and Molar Masses **D11** Mass to Mole Calculations **D13** Lab D2 - Mass to Moles **D14** Mole to Mass Calculations **D15** Definitions **D20** Optional Exercises **D21** Overview **D17 Biography:** Amedeo Avogadro (1776-1856) **D8**

Unit E: Gravimetric Stoichiometry (E1-E24)

Topics: Objectives, Practical Importance of Stoichiometry **E1** Mole to Mole Stoichiometry **E2** Demo E1 - The Reaction of Copper with Aqueous Silver Nitrate **E5** Moles to Mass Stoichiometry **E8** Mass to Moles Stoichiometry **E9** Mass to Mass

Stoichiometry **E10** Lab E1 - A Precipitation Reaction **E11** Lavoisier and the Law of Conservation of Mass **E17** Overview **E19** Review **E21** **Biography:** Antoine Laurent Lavoisier (1743-1794) **E17** **Bibliography E24**

F. ALCHEM 20

Unit F: Review of Chemistry 10 (F1-F36)

Topics: Part 1: Atomic Structure **F1** Chemical Nomenclature **F9** Chemical Reactions **F14** Lab F1 - Safety and Efficiency in the Laboratory **F17** Part 2: Significant Digits and SI **F19** The Mole **F23** Gravimetric Stoichiometry **F28** Lab F2 - The Reaction of Sodium Bicarbonate with Hydrochloric Acid **F29** Unit F Answer Key **F35**

Unit G: Chemical Bonding (G1-G40)

Topics: Objectives, Theory of Covalent Bonding **G1** Lewis Diagrams of Atoms and Molecules **G2** VSEPR Theory (Stereochemistry) **G8** Lab G1 - Shapes Around Central Atoms **G12** Polarity of Bonds and Molecules **G14** Van der Waal (Dipole-Dipole and London Dispersion) Forces **G22** Hydrogen Bonding **G25** Ionic Bonding **G31** Metallic Bonding **G33** Network Covalent Bonding **G34** Relative Strengths of Intermolecular Bonds **G35** Overview **G36** **Biographies:** Gilbert Newton Lewis (1875-1946) and R. J. Gillespie (1924-) **G4**

Unit H: Organic Chemistry (H1-H64)

Topics: Objectives, The Structural Formulas, Nomenclature, Chemical Reactions, Physical Properties, Uses and Sources of: Alkanes **H2** (Demo H1 - Fractional Distillation **H11**) Alkenes **H14** (Lab H1 - Molecular Models of Alkanes and Alkenes **H16**) Cycloalkanes and Cycloalkenes **H21** Alkynes **H24** Aromatics **H29** (Lab H2 - Reactions of Cyclohexane, Cyclohexene and Benzene **H36**) Alkyl Halides **H39** Alcohols **H44** Carboxylic Acids **H50** Esters **H54** (Lab H3 - Esterification **H57**) Overview **H59** CRC Handbook Exercise **H64** **Biography:** Fredrick Wohler (1800-1882) **H1**

Unit I: Solutions (I1-I154)

Topics: Objectives, Introduction **I1** Molar Concentration **I2** Solution Problems **I2** Demo I1 - Preparation of a Solution **I7** Demo I2 - Pipetting Techniques **I14** Dilution **I19** Saturated Solutions and Chemical Equilibrium **I22** Solubility **I24** Factors that Affect Solubility **I26** Demo I3 - Electrolytes and Nonelectrolytes **I28** Ionic Concentrations in Electrolytic Solutions **I32** Overview **I34** **Biography**: Svante August Arrhenius (1859-1927) **I30**

Optional: Reactions in Solution **I36** Net Ionic Equations **I39** An Alternate Method for Net Ionic Equations **I43** Solution Stoichiometry **I47** Solution Stoichiometry Using Net Ionic Equations **I51** Overvie **I53** **Bibliography** **I54**

G. ALCHEM 30

Unit K: Review of Chemistry 10 and 20 (K1-K40)

Topics: Part 1: Atomic Structure **K1** Classification of Substances **K3** Nomenclature **K4** SI **K7** Significant Digits **K8** The Mole and Molar Concentration **K9** Preparation and Dilution of Solutions and Molar Solubility **K12** Chemical Reactions **K14** Ionic Concentrations **K17** Net Ionic Equations **K19** Stoichiometry **K22** Lab K1 - Safety and Efficiency in the Laboratory **K25** Part 2: Lewis Diagrams **K27** Intermolecular Bonding **K28** Organic Chemistry **K29** Organic Reactions **K36** Unit K Answer Key **K39**

Unit L: Energy (L1-L34)

Topics: Objectives, Introduction (phase, chemical and nuclear changes) **L1** Heat Lost = Head Gained **L6** Measurement of Energy Change **L7** Phase Changes **L10** Molar Heat of Phase Change **L10** Lab L1 - Molar Heat of a Phase Change **L12** Chemical Change **L15** Molar Heat of Chemical Reactions **L16** Lab L2 - Molar Heat of a Chemical Change **L17** Representing Energy Changes **L20** Predicting Heats of Reaction (from molar heats of formation) **L22** Comparing Phase, Chemical and Nuclear Changes **L30** Overview **L32** **Biography**: James Prescott Joule (1818-1889) **L5**

Unit M: Electrochemistry (M1-M66)

Topics: Objectives, Lab M1 - An Introduction to Redox **M1** Half Reactions **M6** Using the Oxidizing and Reducing Agents Table for Redox Reactions **M9** Equilibrium in Redox Reactions **M14** Redox Stoichiometry **M15** Lab M2 - Redox Titration **M17** Electrochemical Cells **M23** E° Values **M25** Lab M3 - Electrochemical Cells **M26** Commercial Batteries **M32** Qualitative Aspects of Electrolysis **M38** Demo M1 - Qualitative Aspects of Electrolysis **M39** Quantitative Aspects of Electrolysis **M48** Chlor-alkali Electrolytic Cells **M55** Downs Process **M57** Overview **M59** **Biography**:Sir Humphry Davy (1778-1829) **M45**

Unit N: Acids and Bases (N1-N62)

Topics: Objectives, Classification of Solutions **N1** Demo N1 - Classification of Solutions **N2** Definitions of Acids and Bases **N4** Equilibrium **N7** Special Nature of Water **N8** Equilibrium and the LeChatelier Principle **N9** Equilibrium Constant for Water **N10** pH **N12** Demo N2 - pH of Common Substances **N14** pH Calculations **N15** Demo N3 - pH of Acids and Bases **N20** Strength Versus Concentration for Acids and Bases **N21** Bronsted-Lowry Theory **N24** Writing Acid-Base Reactions **N26** Lab N1 - Bronsted-Lowry Reactions **N31** Polyprotic Acids and Polybasic Species **N34** Stoichiometric Acid-Base Titrations **N38** Titrations and Indicators **N45** Lab N2 - Standardization Titration **N48** Buffers **N55** **Bibliography** **N60** ALCHEM 30 Data Sheet **N61**

H. ALCHEM Electives (Available separately) (level)

Unit J: Analytical Chemistry (20, 30)
Unit O: Foods and Their Analogs (30, 20)
Unit -: The Athabasca Tar Sands (30, 20)
Unit P: Ethylene and its Derivatives (30)
Unit S: Alberta Chemical Industries (10)
Unit T: Metallurgy and Corrosion (30)
Unit U: Nuclear Chemistry (30, 20)

I. Other ALCHEM Materials

1. ALCHEM 10 Teachers' Guide
2. ALCHEM 20 Teachers' Guide
3. ALCHEM 30 Teachers' Guide
4. ALCHEM Electives Teachers' Guide
5. ALCHEM periodic table (student)
6. ALCHEM 30 data sheet (student)
7. ALCHEM 10 Test Item Bank (1979)
8. ALCHEM 20 Test Item Bank (1979)
9. ALCHEM 30 Test Item Bank (1979)
10. ALCHEM periodic table (wall chart) - Side 1 (1979)
11. ALCHEM periodic table (wall chart) - Side 2 (1979)
12. ALCHEM 30 data sheet (wall chart) - Side 1 (1979)
13. ALCHEM 30 data sheet (wall chart) - Side 2 (1979)
14. Tar Sands wall chart
15. ALCHEM mole poster
16. ALCHEM illustrated, biography posters

APPENDIX C

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A. Observation Sheet - The Classroom/Lab

1. Main Features:
2. Windows(W):
3. Blackboards(Bb):
4. Tackboards(Tb):
5. AV Equipment(AV):
6. Special Equipment(Sp):
7. Shelves and Cupboards(S / C):

8. Wall Charts

9. Posters:

10. Desks:

11. Clippings:

12. Other:

B. Observation Sheet - Teaching Strategies

1. Teacher Activity:

2. Student Activity:

3. Use of ALCHEM:

4. Comments on Science:

5. Comments on Students:

6. Comments on Teaching:

7. Comments on Society:

8. General Comments:

APPENDIX D

STUDENT OPINION SURVEY ON THE ALCHEM 10 TEXT

This questionnaire is part of an evaluation of the ALCHEM program. This part of the evaluation focuses on the ALCHEM 10 text which you have been using for your Chemistry 10 course. In the questionnaire you are asked to give your opinion of fourteen different aspects of the material. In each case an example is given, but you are asked to give your opinion of that feature in general, not just the particular example.

You are asked to consider each aspect of the ALCHEM 10 text from the following three points of view:

1. usefulness in helping you gain an understanding of chemistry
2. usefulness in helping you prepare for Chemistry 10 exams
3. whether or not you find the information or exercise interesting

Each rating is done on a five point scale, where "1" is the low end of the scale and "5" is the high end. Use an HB pencil to shade in the appropriate number on the answer sheet.

The lab on safety and efficiency in the laboratory:

Procedure and Questions:

1 Where is the safety station located? ____________________

2 a Where is the fire extinguisher located? ____________________

b What is the type of the fire extinguisher? ____________________

c On what type of fire is the extinguisher effective? ____________________

d How is the fire extinguisher operated? ____________________

e How may a towel be use extinguish a fire? ____________________

1.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

2.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

3.interesting exercise?
>1(boring)..2.......3.......4.......5(very interesting)

The objectives listed at the beginning of each unit, for example:

Upon completion of Unit B the student should be able to:

B1. indicate why (in terms of electrons) ionic and covalent bonds form

B2. use a periodic table to predict whether an ionic or a covalent bond is formed between two atoms

B3. use chemical and physical properties to distinguish between ionic and molecular substances

B4. write formulas of and name ionic compounds, molecular compounds, acids, elements and some common substances

4.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

5.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

6.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The explanations of chemical concepts and principles, such as:

Hydrated Compounds

A number of ionic compounds called *hydrates* produce water when they decompose upon heating. When the formula of a hydrated compound is written, the number of water molecules is also included. For example, the formula for copper(II) sulfate pentahydrate is written as $CuSO_4 \bullet 5H_2O$. The name for $CuSO_4 \bullet 5H_2O$ is copper(II) sulfate pentahydrate indicating that five molecules of water are bonded within the ionic crystal for every one formula unit of $CuSO_4$.

7.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

8.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

9.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The work sheets which require completion of tables, for example:

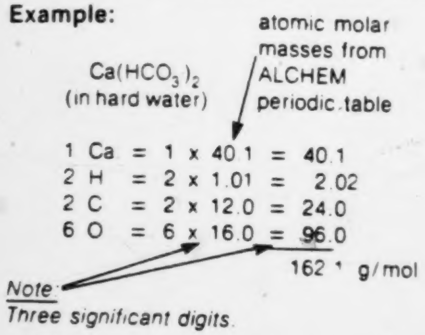
	i or m	Chemical Formula	Name of Compound
1.		K_2CO_3	
2.		$(NH_4)_2S$	
3.			calcium hydroxide
4.			magnesium silicate

10.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

11.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

12.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The worked out examples of mathematical problems, such as:



Example:

$Ca(HCO_3)_2$
(in hard water)

atomic molar
masses from
ALCHEM
periodic table

1 Ca = 1 x 40.1 = 40.1
2 H = 2 x 1.01 = 2.02
2 C = 2 x 12.0 = 24.0
6 O = 6 x 16.0 = 96.0

162.1 g/mol

Note
Three significant digits.

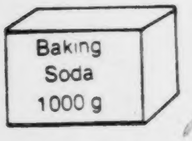
13.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

14.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

15.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The mathematical problems, for example:

Determine the number of moles in a 1000 g (1.000 kg) container of each of the following. Show all work exactly as in the example. Use correct SI symbols and significant digits.



$(NaHCO_3)$

16.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

17.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

18.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The demonstrations, such as:

TYPES OF CHEMICAL REACTIONS — DEMO C1

Purpose:

1. To identify six types of chemical reactions.
2. To provide examples of the six types of chemical reactions.
3. To introduce balancing of chemical equations.

19.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

20.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

21.interesting?
>1(boring)..2.......3.......4.......5(very interesting)

The overview exercises at the end of each Unit, for example:

COMPOUNDS, BONDING AND NOMENCLATURE
OVERVIEW

1. Molecules are formed when electrons are *shared* between (simultaneously attracted to) ____________

2. List the formulas for six *molecular* monoatomic elements.

a. ________ b. ________ c. ________ d. ________ e. ________ f. ________

3. List the formulas for eight *molecular* diatomic elements.

a. ______ b. ______ c. ______ d. ______ e. ______ f. ______ g. ______ h. ______

22.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

23.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

24.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The lab work, such as:

PROPERTIES AND APPLICATIONS OF ELEMENTS — LAB A2

Purpose:

1. To distinguish among some elements in terms of their physical and chemical properties.
2. To practice some observation skills.
3. To distinguish between metals and nonmetals.
4. To learn to use the terms - ore, alloy, plated and oxide.
5. To become acquainted with some common uses of elements.

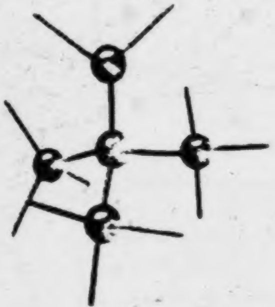
25.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

26.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

27.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The illustrations, such as:

diamond



28.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

29.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

30.interesting?
>1(boring)..2.......3.......4.......5(very interesting)

The biographical sketches, for example:

Dmitri Mendeleev (1834 - 1907)

Dmitri Ivanovich Mendeleev, the youngest of seventeen children, was born in Tobolska Siberia on February 7, 1834. Mendeleev's grandfather had brought a printing press to Siberia and published the first newspaper in the region. His father was principal of the local high school until blindness forced an early retirement. Since the disability pension that his father received wasn't enough to support the family, Mendeleev's mother set up a glass factory in order to make ends meet. As a young boy Mendeleev received his first lessons in science from a political prisoner who had been exiled to Siberia.

31.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

32.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

33.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The information that is provided in the problems and worksheets about the sources and uses of chemicals, for example:

Chemical Formula	Description or Use [*for interest only*]	Name of Compound
e.g., $CaCl_2$	white solid, wetting agent	calcium chloride
	dietary supplement for iodine	potassium iodide
MgO	white powder; magnesium ore	
	antiperspirant	aluminum chloride

34.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

35.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

36.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The worksheet on the film, Chemical Families:

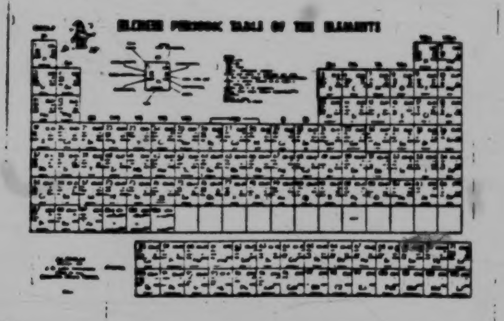
Elements Combined	Reaction	No Reaction
phosphorus (P_4) with hydrogen (H_2)		
phosphorus (P_4) with fluorine (F_2)	✓ (Table A3)	
phosphorus (P_4) with chlorine (Cl_2)		
phosphorus (P_4) with bromine (Br_2)		
phosphorus (P_4) with iodine (I_2)		

37.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

38.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

39.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The periodic table provided in the ALCHEM 10 text:



40.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

41.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

42.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

1

STUDENT OPINION SURVEY ON THE ALCHEM 30 TEXT

This questionnaire is part of an evaluation of the ALCHEM program. This part of the evaluation focuses on the ALCHEM 30 text which you have been using for your Chemistry 30 course. In this questionnaire you are asked to give your opinion of fourteen different aspects of the material. In each case an example is given, but you are asked to give your opinion of that feature in general, not just the particular example.

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1. usefulness in helping you gain an understanding of chemistry
2. usefulness in helping you prepare for Chemistry 30 exams
3. whether or not you find the information or exercise interesting

Each rating is done on a five point scale, where "1" is the low end of the scale and "5" is the high end. Use an HB pencil to shade in the appropriate number on the answer sheet.

The review of Chemistry 10 and 20 at the beginning of the ALCHEM 30 text:

REVIEW OF CHEMISTRY 10 & 20

ATOMIC STRUCTURE AND CHEMICAL SPECIES

Match the letter of each term from the left column with the definitions in the right column.

a. nucleus

b. proton

c. neutron

___ 1. the electrons in the outermost energy level of an atom.

___ 2. an element that can form negative ions. These elements are dull in appearance, brittle and conduct heat and electricity very poorly. They are generally located on the right side of the staircase line on the periodic table.

1.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

2.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

3.interesting information and exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The objectives listed at the beginning of each unit, for example:

After studying Unit M, *Electrochemistry*, the student should be able to:

M1. define and use the terms - reduction, oxidation, oxidizing agent, and reducing agent

M2. use experimental data to rank oxidizing agents and reducing agents in order of strength

M3. write equations for half reactions for redox reactions

M4. use reduction potential tables to predict the most likely redox reaction in a given chemical system, to balance the net ionic equation for the reaction, and to determine whether or not the reaction is spontaneous (in terms of strengths of oxidizing agents or E° values)

4.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

5.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

6.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The explanations of chemical concepts and principles, such as:

Commercial Cells

Several types of electrochemical cells and batteries are available commercially. Batteries are made by connecting two or more cells in series so that the voltage of the battery is the sum of the voltages of the individual cells. Some commercial cells cannot be effectively recharged so when the chemicals in the cell eventually become exhausted the cell must be replaced. Other commercial cells can be recharged by reversing the current through the cell by means of a battery charger.

7.useful for gaining an understanding of chemistry?

>1(useless).2.......3.......4.......5(very useful)

8.useful in preparing for exams?

>1(useless).2.......3.......4.......5(very useful)

9.interesting information?

>1(boring)..2.......3.......4.......5(very interesting)

The work sheets which require completion of tables, for example:

	i, m or a	Chemical Formula	Common Name and/or Use	Chemical Name of Substance
1.			rust remover	phosphoric acid
2		$NaNO_{2(s)}$	meat preserver	

10.useful for gaining an understanding of chemistry?

>1(useless).2.......3.......4.......5(very useful)

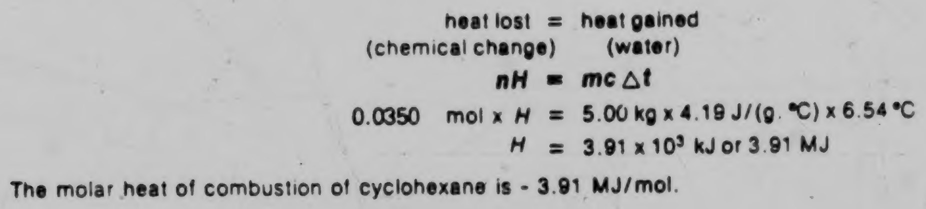
11.useful in preparing for exams?

>1(useless).2.......3.......4.......5(very useful)

12.interesting exercises?

>1(boring)..2.......3.......4.......5(very interesting)

The worked out examples of mathematical problems, such as:



$$\begin{aligned} \text{heat lost} &= \text{heat gained} \\ \text{(chemical change)} &\quad \text{(water)} \\ nH &= mc\Delta t \\ 0.0350 \text{ mol} \times H &= 5.00 \text{ kg} \times 4.19 \text{ J/(g} \cdot {}^\circ\text{C)} \times 6.54\,{}^\circ\text{C} \\ H &= 3.91 \times 10^3 \text{ kJ or } 3.91 \text{ MJ} \end{aligned}$$

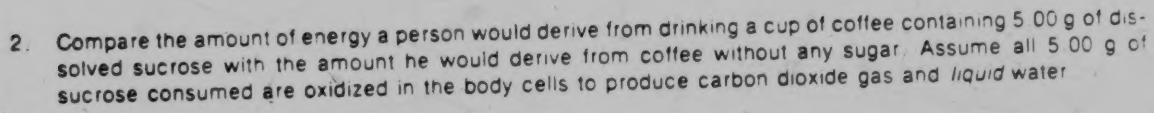
The molar heat of combustion of cyclohexane is - 3.91 MJ/mol.

13.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

14.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

15.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The mathematical problems, for example:



2. Compare the amount of energy a person would derive from drinking a cup of coffee containing 5.00 g of dissolved sucrose with the amount he would derive from coffee without any sugar. Assume all 5.00 g of sucrose consumed are oxidized in the body cells to produce carbon dioxide gas and *liquid* water.

16.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

17.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

18.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The demonstrations, such as:

QUALITATIVE ASPECTS OF ELECTROLYSIS — DEMO M1

Procedure:

Electrolysis of Aqueous Potassium Iodide (U-tube)

1. The U-tube assembly should be attached by a utility clamp to a ring stand.
2. Fill the U-tube with potassium iodide solution. Place a carbon electrode in each end of the U-tube.

19.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

20.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

21.interesting?
>1(boring)..2.......3.......4.......5(very interesting)

The overview exercises at the end of each Unit, for example:

L12,L13,L24 L32

ENERGY
OVERVIEW

Phase changes, chemical changes and nuclear changes all involve changes in energy. Questions 1 to 4 involve reactions that can be used as commercial sources of energy.

22.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

23.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

24.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The lab work, such as:

AN INTRODUCTION TO REDOX — LAB M1

Materials:

1 - test tube rack

16 - clean 13 x 100 mm test tubes

4 - 4 x 100 mm (approx.) strips of each of the metals - copper, zinc, lead, and silver

15 mL of 0.10 mol/L $Cu(NO_3)_{2(aq)}$

15 mL of 0.10 mol/L $Zn(NO_3)_{2(aq)}$

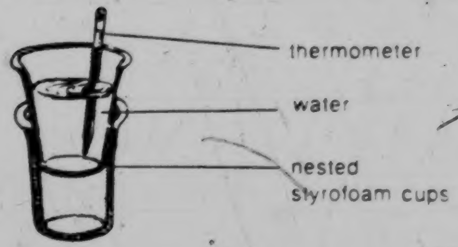
25.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

26.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

27.interesting exercises?
>1(boring)..2.......3.......4.......5(very interesting)

The illustrations, such as:

Simple Calorimeter



A Simple Calorimeter
Figure L3

28.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

29.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

30.interesting?
>1(boring)..2.......3.......4.......5(very interesting)

The biographical sketches, for example:

James Prescott Joule (1818 - 1889)

> James Prescott Joule was the son of a brewery owner in Manchester, England. Coming from a very wealthy family, Joule was able to devote much of his time to study and research. He received some instruction from John Dalton but he was mostly self-educated.
>
> Joule was a superb experimenter, almost fanatical about measuring the heat produced in just about any kind of process. In every case he

31.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

32.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

33.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The information that is provided in the problems and worksheets about the sources and uses of chemicals, for example:

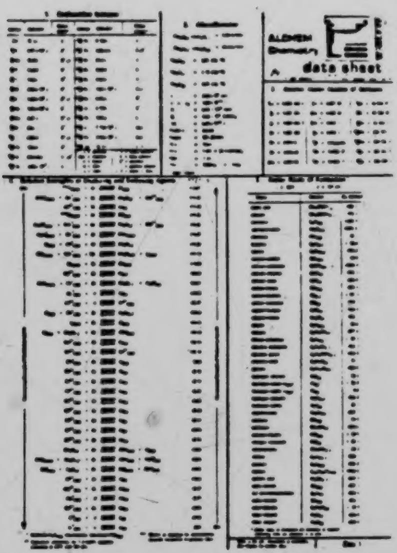
> 1. The Sheritt-Gordon Nickel Refinery at Fort Saskatchewan synthesizes hundreds of tonnes of ammonia NH_3, in a reaction called the *Haber Process* Nitrogen gas and hydrogen gas are reacted at high temperature and pressure to produce ammonia. Calculate the heat of reaction and the molar heat of reaction for ammonia using the equation below.
>
> $$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$$

34.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

35.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

36.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The ALCHEM data sheet:



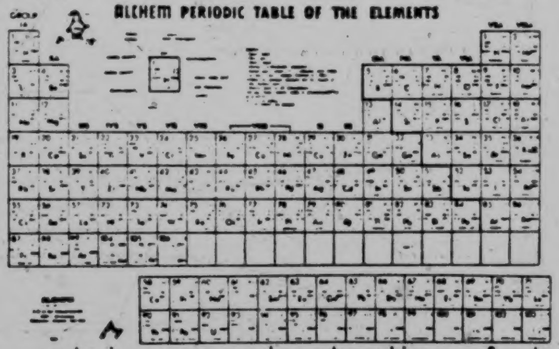
data sheet

37.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

38.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

39.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

The periodic table provided in the ALCHEM 30 text:



ALCHEM PERIODIC TABLE OF THE ELEMENTS

40.useful for gaining an understanding of chemistry?
>1(useless).2.......3.......4.......5(very useful)

41.useful in preparing for exams?
>1(useless).2.......3.......4.......5(very useful)

42.interesting information?
>1(boring)..2.......3.......4.......5(very interesting)

APPENDIX E

A QUESTIONNAIRE FOR CHEMISTRY TEACHERS

Chemistry Classroom Practice Survey

Please write all your responses in the questionnaire booklet.

Do not write your name on the questionnaire.

Use the envelope provided to return the completed questionnaire to:

Oliver C. Lantz
Department of Secondary Education
338 Education South
University of Alberta
Edmonton, Alberta
T6G 2E1

If you have any questions regarding the questionnaire, please phone Oliver Lantz at (403) 432-5415.

This questionnaire is part of a study of the role of teachers' practical knowledge in translating the intended high school chemistry curriculum into classroom practice. The study has a particular interest in teacher use of the ALCHEM materials.

Section 1 - Background Information

This section is designed to gather some information about you and the school in which you teach. This background information will aid interpretation of your opinions.

For each question, circle the letter of the appropriate response.

1. What is your age?
   A under 26
   B 26 - 35
   C 36 - 45
   D 46 - 55
   E over 55

2. What is your sex?
   A Male
   B Female

3. How many years of teaching experience (including the current year) do you have?
   A 1 year
   B 2 - 5 years
   C 6 - 9 years
   D 10 - 13 years
   E 14 years or more

4. How many years of experience (including the current year) do you have teaching high school chemistry?
   A 1 year
   B 2 - 5 years
   C 6 - 9 years
   D 10 - 13 years
   E 14 years or more

5. How many different courses are you teaching at present? (consider Chemistry 10, 20, and 30 as three separate courses)
   A 1
   B 2
   C 3
   D 4
   E 5 or more (please specify how many)________________

6. In the current school term, how many different students are you teaching?
   A less than 50
   B 50 - 99
   C 100 - 149
   D 150 - 199
   E 200 or more

7. In the current school term, what percentage of your teaching load is comprised of teaching chemistry?
   A. less than 20%
   B. 20% - 39%
   C. 40% - 59%
   D. 60% - 79%
   E. 80% - 100%

8. What is your area of specialization?
   A. Physical Science
   B. General Science
   C. Biological Science
   D. Mathematics
   E. Physical Education
   F. Home Economics
   G. Other (please specify the area)______________________________

9. How many courses in chemistry did you complete during your post-secondary education? (Indicate in terms of full year courses. A one-term or semester course would be considered half a course.)
   A. 1 or less
   B. 1.5 - 3
   C. 3.5 - 5
   D. 5.5 - 7
   E. 7.5 or more

10. How many courses in science education did you complete during your post-secondary education? (Indicate in terms of full year courses. A one-term or semester course would be considered half a course.)
    A. 1 or less
    B. 1.5 - 2
    C. 2.5 - 3
    D. 3.5 - 4
    E. 4.5 or more

11. How do you rate the adequacy of your background for teaching high school chemistry?
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

12. How do you rate your training and/or experience in chemistry lab work?
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

13. How do you rate the adequacy of your background for teaching the social implications of science? (e.g., acid rain, nuclear energy)
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

14. How do you rate the adequacy of your background for teaching the nature (i.e., process and philosophy) of science?
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

15. How would you rate the facilities in your school for teaching chemistry?
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

16. Generally, how would you describe the attitude of your students toward learning chemistry?
    A. Excellent
    B. Good
    C. Satisfactory
    D. Unsatisfactory
    E. Very Unsatisfactory

17. What grades does your school include?
    A. K or 1 - 12
    B. 7 - 12
    C. 10 - 12
    D. Other (please specify)________________________________

18. What is the approximate number of full time teachers in your school?
    A. 1 - 19
    B. 20 - 39
    C. 40 - 59
    D. 60 - 79
    E. 80 or more

19. How many chemistry teachers are there in your school?
    A. 1 - 2
    B. 3 - 4
    C. 5 - 6
    D. 7 - 8
    E. 9 or more

20. What is the population of the community (i.e., city, town, or village) where your school is located?
    A. less than 1000
    B. 1000 - 4999
    C. 5000 - 29 999
    D. 30 000 - 99 999
    E. 100 000 or more

Section 2 - Objectives of the Alberta Chemistry Program

The following objectives are taken from the Alberta Education document, *Curriculum Guide for Senior High School Chemistry (1977)*. A five-point rating scale is provided after each objective. As shown below, "1" is the low end of the scale (no emphasis), and "5" is the high end (heavy emphasis).

no emphasis 1..........2..........3..........4..........5 heavy emphasis

For each item, circle the number which represents the emphasis you place on that objective in your own chemistry teaching.

21. Develop skill in the methods used by chemists such as processes in scientific inquiry observing, hypothesizing, classifying, experimenting, and interpreting data
1..........2..........3..........4..........5

22. Develop skill in the methods used by chemists such as skills in the cognitive, affective, and psychomotor domains
1..........2..........3..........4..........5

23. Develop skill in the methods used by chemists such as skills in individual and group problem solving
1..........2..........3..........4..........5

24. Acquire a working knowledge of the fundamental ideas in chemistry
1..........2..........3..........4..........5

25. Acquire a working knowledge of the application of the fundamental ideas of chemistry
1..........2..........3..........4..........5

26. Acquire a working knowledge of the interrelationships among the different sciences and mathematics
1..........2..........3..........4..........5

27. Acquire a working knowledge of the tentativeness of chemical theory
1..........2..........3..........4..........5

28. Acquire a background knowledge about such issues as use and depletion of natural resources
1..........2..........3..........4..........5

29. Acquire a background knowledge about such issues as chemistry of environmental pollution.

1........................2........................3........................4........................5

30. Acquire a background knowledge about such issues as use and misuse of chemicals such as preservatives, additives, insecticides, etc.

1........................2........................3........................4........................5

31. Acquire a background of knowledge and experiences in the application of chemistry such as chemistry in the home

1........................2........................3........................4........................5

32. Acquire a background of knowledge and experiences in the application of chemistry such as leisure-time activities such as photography, automotives, etc

1........................2........................3........................4........................5

33. Acquire a background of knowledge and experiences in the application of chemistry such as consumer chemistry.

1........................2........................3........................4........................5

34. Acquire a background of knowledge and experiences in the application of chemistry such as chemistry in industry.

1........................2........................3........................4........................5

35. Develop an awareness and critical understanding for decision-making on value issues arising out of the use and misuse of chemistry.

1........................2........................3........................4........................5

36. Acquire a knowledge and appreciation of the history and philosophy of chemistry.

1........................2........................3........................4........................5

37. Develop a background of chemical knowledge and skills prerequisite to future careers

1........................2........................3........................4........................5

Section 3 - Selecting and Adapting Curriculum Materials

Selecting and adapting curriculum materials to meet the needs of a particular classroom situation is an integral part of effective teaching In the following section you are asked. to indicate how important you consider certain factors for determining how you use curriculum materials in your chemistry classroom A five-point rating scale is provided after each item As shown below, "1" is the low end of the scale (not important), and "5" is the high end (extremely important).

not important 1..........2..........3..........4..........5 extremely important

For each item, circle the number which represents the importance you attach to that factor.

38 What the students will need to know to succeed in the next level of high school chemistry
1..........2..........3..........4..........5

39 What students will need to know to succeed in their postsecondary education (university technical school, nursing etc.)
1..........2..........3..........4..........5

40 What students need to know to understand the impact of chemistry in their daily life
1..........2..........3..........4..........5

41. What society needs by way of informed citizens
1..........2..........3..........4..........5

42 What students require to understand the principles of chemistry
1..........2..........3..........4..........5

43 What students require to understand the historical development of chemistry
1..........2..........3..........4..........5

44 What students will enjoy and find personally interesting
1..........2..........3..........4..........5

45 The students' background in science
1..........2..........3..........4..........5

46 The guidelines given in the Chemistry Curriculum Guide
1..........2..........3..........4..........5

47. The students ability
1..........2..........3..........4..........5

48 The time available
1..........2..........3..........4..........5

49 The facilities available
1..........2..........3..........4..........5

50 Approaches that have worked well for you in the past
1..........2..........3..........4..........5

51. Your own interests, background and preferences
1..........2..........3..........4..........5

Section 4 - Teaching Strategies

In the following section you are asked to indicate how frequently you use particular teaching methods in your chemistry classes.

In each item, circle the letter of the appropriate response

52 Lectures
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

53 Student lab work
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

54 Teacher demonstrations
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

55 Anecdotes and examples from your own background and experience
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

56 Your own worksheets
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

57 Supplementary lab work (i.e., other than the labs provided in the student materials)
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

58 Supplementary notes (i.e., in addition to the information provided in the student materials)
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

59 Films or videotapes
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

60 Newspaper or magazine articles
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

61 Guest speakers
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

62 Computer lessons or simulations
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

63 Field trips to local industries or institutions
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

64 Tests or quizes
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

65 Having students put homework on the blackboard
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

66 Having students hand in lab reports for evaluation
A Never or rarely
B About once or twice a semester
C About once or twice a month
D About once or twice a week
E Almost every class period

67 Have you ever used any of the ALCHEM materials in teaching high school chemistry?
A No
B Yes

If you have never used the ALCHEM materials, do not complete the remaining two sections of the questionnaire. Please return the questionnaire to the researcher as indicated on the front page. Thank you for your cooperation.

If you have used the ALCHEM materials, please complete the remaining two sections before returning the questionnaire to the researcher.

Section 5 - Rating the ALCHEM materials

In the following questions, circle the letter of the appropriate response.

68 How many years experience (including the current year) do you have using ALCHEM materials?
A 1 year
B 2 - 3 years
C 4 - 5 years
D 6 - 7 years
E 8 years or more

69 In which chemistry courses have you used ALCHEM materials? (circle as many as necessary)
A Chemistry 10
B Chemistry 20
C Chemistry 30
D Other (please specify the course)__________________________

70 How would you describe the way you have used ALCHEM?
A As a textbook for the course
B In conjunction with another text
C Selected pages to supplement another text

71 In general, how would you rate the ALCHEM materials?
A Excellent
B Good
C Satisfactory
D Unsatisfactory
E Very Unsatisfactory

In the remaining items in this section you are asked to rate certain aspects of the ALCHEM materials on the basis of their usefulness to you in teaching high school chemistry. Again, the ratings are done on a five point scale, where "1" is the low end (useless), and "5" is the high end (very useful).

useless 1..........2..........3..........4..........5 very useful

For each item, circle the number which reflects your opinion

72 The objectives listed at the beginning of each unit
1..........2..........3..........4..........5

73 The explanations of chemical concepts and principles
1..........2..........3..........4..........5

74 The work sheets which require completion of tables
1..........2..........3..........4..........5

75 The worked out examples of problems (sample solutions)
1..........2..........3..........4..........5

76 The worksheets which require solving problems
1..........2..........3..........4..........5

77 The demonstrations
1..........2..........3..........4..........5

78 The overview exercises at the end of each unit
1..........2..........3..........4..........5

79 The lab work
1..........2..........3..........4..........5

80 The illustrations
1..........2..........3..........4..........5

81 The biographical sketches
1..........2..........3..........4..........5

82 The information that is provided in the problems and worksheets about the sources and uses of chemicals
1..........2..........3..........4..........5

83 The periodic table provided in the ALCHEM text
1..........2..........3..........4..........5

Section 6 - Comments on ALCHEM

Please answer the following questions briefly in the spaces provided. Use the reverse side of the page if necessary.

84. In general what is your opinion of the ALCHEM materials?

85. Are there any parts of ALCHEM that you omit? (e.g., labs, demos, exercises) If so, what are they and why do you omit them?

86 Are there any parts of ALCHEM that you supplement? (e.g. with films, additional notes, labs, or demos)
If so, what are they and how do you supplement them?

87 Are there any parts of ALCHEM that you adapt or modify?
If so, what are they and how do you adapt them?

88 Which elective units do you use, and how much time do you spend on them?

A major revision of the ALCHEM materials is planned for the near future.

89 In your opinion, what should be added to the revised ALCHEM materials?

90 In your opinion, what items should be removed from the ALCHEM materials?

APPENDIX F

A. Letter to Superintendents

Department of Secondary Education
338 Education South
University of Alberta
Edmonton, Alberta
T6G 2E1
April 29, 1983

Dr. A. J. Smith
Superintendent of Schools
Foothills School District #99
Clearvisa, Alberta

Dear Dr. Smith

I am a doctoral student in science education, enrolled in the Department of Secondary Education at the University of Alberta. Under the direction of my advisor, Dr. Heidi Kass, I am currently engaged in collecting the data for my Ph. D. dissertation.

My dissertation research is an investigation of the role of teachers practical knowledge in translating the chemistry curriculum into classroom practice. The chemistry curriculum is taken to be the program outlined in the *Chemistry 10, 20, 30 curriculum guide* (Alberta Education, 1977). Classroom practice refers to the learning activities planned and carried out by the teacher. I wish to examine how the teacher translates the chemistry curriculum into classroom experiences for students, and to identify some of the factors which teachers consider in making this translation. There is currently a great deal of interest and activity in this area of curriculum research. I believe that my study will contribute to the growing body of knowledge in this important area. The data collected in my research should be of particular interest to science educators and curriculum developers.

The current phase of the research involves having chemistry teachers respond in confidence to a survey questionnaire. The questionnaire is designed to capture basic descriptive data, with particular emphasis on the ALCHEM materials. The questionnaire takes about 50 minutes to complete and does not require any class time. All responses will be aggregated so the anonymity of the teachers, schools, and system will be preserved. A copy of the questionnaire is enclosed.

The sample for the study was drawn by randomly selecting one-fifth of the high schools in Alberta. The following schools from your jurisdiction have been selected to be part of the study sample:

Wildrose High School

Mountainview High School

I would like your permission to contact the principals of the above schools, to request the cooperation of the chemistry teachers in completing the survey questionnaire. I would like to mail the questionnaires to the schools early in May.

Please complete, detach, and return the form at the bottom of the page. If you have any questions regarding my research, please call me at (403) 432-5415.

I look forward to your prompt and favorable reply.

Yours truly,

Oliver C. Lantz

Enclosure

* *

May I have your permission to contact the principals of the following schools, in regard to my study?

Wildrose High School

Mountainview High School

Yes ____________ No ____________

Signed ______________________________

Foothills School District #99

B. Letter to Principals

Department of Secondary Education
338 Education South
University of Alberta
Edmonton, Alberta
T6G 2E1
May 9, 1983

Mr. Y. H. Jones
Principal
Wildrose High School
Wildrose, Alberta

Dear Mr. Jones,

I am a doctoral student in science education, enrolled in the Department of Secondary Education at the University of Alberta. Under the direction of my advisor, Dr. Heidi Kass, I am currently engaged in collecting the data for my Ph. D. dissertation.

My dissertation research is an investigation of the role of teachers' practical knowledge in translating the chemistry curriculum into classroom practice. The chemistry curriculum is taken to be the program outlined in the *Chemistry 10, 20, 30 curriculum guide* (Alberta Education, 1977). Classroom practice refers to the learning activities planned and carried out by the teacher. I wish to examine how the teacher translates the chemistry curriculum into classroom experiences for students, and to identify some of the factors which teachers consider in making this translation.

The current phase of the research involves having chemistry teachers respond in confidence to a questionnaire, the *Chemistry Classroom Practice Survey*. The survey questionnaire is designed to capture basic descriptive data, with particular emphasis on the ALCHEM materials. Copies of the questionnaire are enclosed. The questionnaire takes about 50 minutes to complete and does not require any class time. All responses will be aggregated so the anonymity of the teachers, school, and system will be preserved.

The sample for the study was drawn by randomly selecting one-fifth of the high schools in Alberta. Your school has been selected to be part of the study sample, and I have received permission from the Superintendent of your school jurisdiction to contact you regarding my study. Would you pass along the enclosed copies of the *Chemistry Classroom Practice Survey* to the chemistry teachers in your school with the request that they complete the questionnaire and return it to me? I realize that this is a very busy time of year for you and your teachers, and I very much appreciate your cooperation in this matter.

I have supplied a stamped, addressed envelope for returning the questionnaires. Perhaps you could designate someone to collect the completed questionnaires and return them to me. I would like them returned by the end of May, if possible. If you have any questions regarding my research, please call me at (403) 432-5415.

Yours truly,

Oliver C. Lantz

Enclosure

APPENDIX G

A. Observation Notes from Parkland High School

The School

-the school is in a two-storey brick building which includes an auditorium and a large gym.
-building is generally well appointed, but showing some signs of wear.
-Canadian Centennial symbol in main foyer indicates that school was built in 1967.
-pleasant, casual atmosphere in the hallways.
-students in hallway respond courteously to my requests for direction, give way in the entrance, watch me with some curiosity. (Perhaps outside visitors are not as frequent here as in the city schools.)
-teachers in hallway nod, smile, and look a little curious.
-office staff are very accommodating.
-the Assistant Principal (AP) responsible for the science program gave following information on the community:
    -population of town is approximately 5000.
    -growth has slowed since recession hit.
    -main occupations in town are providing agricultural & oilfield service, a federal agricultural research station, a provincial hail & crop research station, and a tree nursery.
    -newly built gas plant nearby does not employ many people from the town.
-AP gave following information on the school:
    -enrollment is approximately 600, about 40% from the town and 60% from the surrounding area.
    -school has been on the semester system for the past 10 years.
    -school has 4 science teachers, but since the enrollment has dropped not all can teach science full time.
    -vocational wing serves the whole county and draws about 40 students from outside the regular attendance area.
    -proportion of matriculation students drops from about 80% in grade 10 to 50% in grade 12.

The Program

-AP gave me a copy of the "Student Handbook" for Parkland High, which includes the following information:
    -an explanation on the school's policy on attendance & evaluation.
    -an outline of the requirements for general H.S. diploma and matriculation.
    -a description of the programs and courses offered by the school.
-AP gave following enrollments for science courses:
    -Biol 10/20/30=130/90/70.
    -Chem 10/20/30=85/90/50.
    -Phys 10/20/30= 110/65/40.
    -Science 11=80.
-AP notes that there is, "a fairly high attrition rate", in science courses at Parkland.

Classroom Setting

1. Main Features:
-approx 8 m by 8 m.
-tiered in 4 levels.

2. Windows(W):
-2 large windows in rear right corner of classroom, looks out onto a town park.

3. Blackboards(Bb):
-green boards along the front and left walls.

4. Tackboards(Tb):
-large boards along the rear and right walls.

5. AV Equipment(AV):
-screen mounted permanently from ceiling in front left corner.

6. Special Equipment(Sp):
-base for gas discharge tubes sitting on demo desk.

7. Shelves and Cupboards(S/C):
-2 sets, with glass doors along right wall.

8. Wall Charts:
-Cenco periodic table mounted above side Bb.

9. Posters:
-lab safety series, CANDU reactor, sources of radiation, radiation hazard poster.
-Synergy (YSF / Suncor Youth Symposium in Toronto).
-Edmonton Planetarium.
-Alberta Wheat Pool calendar.

10.Desks:
-teacher's desk on low platform at front beside demo table.
-students' desks are moveable, sloping top, no arms, book rack under seat.

11.Clippings:
-a few newspaper and magazine clippings of:
    -science related news items.
    -science articles.
    -cartoons.

12.Teachers' Office:
-located between classroom and lab, shared by Mr. Allan & Ms. Smith (who teaches some Chem 10 and 20).
-contains 2 desks, 2 file cabinets, 2 book cases.
-bookshelf holds high school and university textbooks on chem, general science, & math, 2 bound volumes of *Chem 13 News*.
-demo slide rule propped against wall. (Allan showed me his new portable microcomputer which he uses to calculate student marks.)

13.Other:
Ms. Smith (who shares the office with Allan) volunteered the following opinions about the ALCHEM materials:
    -"no thought processes" involved in ALCHEM.
    -thinking in ALCHEM is "at a superficial level".
    -"needs a more rigorous approach" to "teach kids to think".
    -chemistry is a science course, therefore "students should work hard and learn to think in chemistry".
    -ALCHEM should be revised by adding "a numerical portion" which includes applications of molar volumes of gases.
    -CHEM Study was a hard course, "I liked that course".
    -(After Ms. Smith's critique, Allan made a few remarks in defence of ALCHEM.)

Teaching Strategies

Classes Observed
-Chem 10 class on atomic structure (Feb. 9).
-Chem 30 class on hydrocarbon nomenclature (Feb. 16).
-Chem 30 review class on gravimetric stoichiometry (Mar. 23).
(About half the class was at a U. of Calgary orientation.)
-Chem 30 class on heat stoichiometry (Apr. 14).

1. Teacher Activity:
(Chem 10, Feb. 9)
-gave quiz on chem symbols & lab equipment. (well coordinated routine where students wrote the test, passed it back and marked it in class, and turned in the marked papers within 10 min.)
-checked students' HW on Bb, and used it to build a lesson on electron energy sub-levels.

(Chem 30, Feb. 16)
-did examples of hydrocarbon nomenclature on the Bb.
-checked student work at Bb and at student desks.
-gave notes on pyrolysis, "off the top of his head".

(Chem 30, Mar. 23)
-gave students worksheet of gravimetric stoichiometry questions.
-provided individual assistance to students as they worked on the stoichiometry problems.

(Chem 30, Apr. 14)
-gave long assignent out of O'Connor on heats of reaction.
-collected lab assignment from O'Connor Lab 27 on heat of combustion of magnesium.
-checked students' homework at Bb on heat calculations from ALCHEM. (He discovered that the answers in the ALCHEM teachers' guide don't match the questions in the '83 edition of the student books.)
-while discussing the HW questions students had difficulty with, he discussed the solutions very carefully, breaking them down, showing the relations among the steps, and attempting to conceptualize a general method or approach.
-he emphasizes the use of ratios in his examples, and draws parallels to everyday situations, such as, "How far can you go on a tank of gas?"

2. Student Activity:
(in all the classes observed)
-selected students put last day's HW on Bb.
-take notes from teacher and textbook.
-complete worksheets from ALCHEM and problems from other references (Keys to Chem, O'Connor, Seinko & Plane).
-apparently do some lab work. (I never observed them in the lab, but I saw them turn in lab reports.)

3. Use of ALCHEM:
-used ALCHEM 10 worksheet on electron energy levels in simple ions.
-used ALCHEM 20 worksheets on hydrocarbon nomenclature.
-used ALCHEM 30 worksheets on thermochemistry.

4. Comments on Science:
-"patterns of energy levels should hold" (i.e., nature should fit our models of it).
-concern was expressed about the "limited power" of the Bohr model of the atom to predict the energy levels in the transition metals. (It seemed to me that he missed an ideal opportunity to discuss the nature of scientific theories and the value of restricted models.)

5. Comments on Students:

-good rapport with students, gently chiding them about errors in arithmetic and spelling, and about incompleted HW.

-students who got library notices about overdue books were sent to the Bb to write out their solutions to last day's HW.

-(I thought the following exchange between Allan and a Chem 30 student was interesting.):

Allan: What's the name of this one, Don?
Student: 2-methylhexane.
Allan: (walking toward student) Are you sure?
Student: Well. . . Uhm. . . .
Allan: Don! Are you sure?
Student: Uhm. . . No.
Allan: Don! How long is the carbon chain?
Student: Six.
Allan: Right, so its hexane, and what's the side chain?
Student: Methyl.
Allan: Right, and where is it attached?
Student: On the second carbon.
Allan: So, 2-methylhexane is right! You followed the rules and it is right. Speak with confidence!

Comments on Teaching:

-careful, systematic discussion of hydrocarbon nomenclature using molecular models.

-draws from a variety of sources for notes and examples.

-uses HW on Bb as a feedback mechanism.

-forces students to think about their calculations and find their own errors, by informing them that they have made an error and sending them back to the board until they find the error and correct it.

Comments on Society:

-stressed the uses of organic compounds which are produced in the community, such as propene. (I asked him about this, and he said that he tried to work in a discussion of the local natural gas industry as much as possible, and regretted that the company didn't give tours of the gas plant.)

General Comments:

-Allan gave me the following materials which he has developed for use in teaching his chemistry classes:

> -3 pages of notes on the periodic table(PT) (history, modern PT, summary of information in PT, nobel gases, old version of PT).
>
> -1 page of study questions on elements (students would need to use Keys to Chem, Seinko & Plane, and CHEM Study text to complete).
>
> -3 page glossary of terms on atomic structure and periodic table.
>
> -1 page data sheet for recording measurements from CHEM Study lab on heat of combustion of magnesium.
>
> -a Chem 30 test on Heats of Reaction, consisting of mathematical calculations and long answer questions, and carrying the following advice, "Work must be shown for problems. Think your problems through carefully and don't make any silly mistakes."
>
> -a final exam and a supplemental exam for the chemistry upgrading course (Chem 10/20 equivalent) that Allan teaches at a nearby Junior College.
>
> The tests are of parallel construction, each including 75 multiple choice items, short answer questions on nomenclature and formula writing, balancing equations, Lewis diagrams, and four calculation questions. (The test includes some items on topics that are not included in the current Alberta core chemistry program, such as, empirical formulas, gas laws, and the quantum model of the atom.)

B. First Interview with Mr. Allan, February 9, 1983

(The interview was conducted in Allan's office at Parkland C.H.S., during lunch hour.)

1. **Lantz:** What I'm trying to find out is how do teachers use ALCHEM, how do they modify and adapt it to make it work for them and then to get at what the reasons are behind those modifications. (Pause) The first question is a general one. What do you think of the ALCHEM materials in general?

2. **Allan:** My main reaction to it is that as an assignment booklet where there are questions, exercises, things of that sort it's excellent. Because finding a suitable selection of questions is often hard to come by. So I like that part very much. My initial reaction to ALCHEM still exists, and that's the explanation part is very limited and for a chemistry course I would like to see a good textbook accompany the course and use the ALCHEM more as a work book supplemental type of material or the converse that the students would have some reference material that they could go and read in addition to what is in the ALCHEM. The material is brief, it's to the point, I think it's clear but there are many students, I think that want a little more, they are looking for other things. This is what I run into at the College too, where there are students who have been out of school for some years, they would like something else to read, to supplement what is there and to supplement lectures and discussions in class.

3. **Lantz:** I think that's a good point. I guess in the origins of it began more or less as providing work sheets which teachers felt were not provided by some of the textbooks that were being used, in CHEM Study in particular, and then gradually added explanations to it. But it's still very slim in that area. You feel then that a number of your students, both here and at the College, would like more background reference material?

4. **Allan:** That is right, and I for this reason, while I think it's a crappy book, I used the *Keys to Chemistry* in the 10 and 20. Not because it's a particularly good book, but it happens to be the one that's available. The grade 12 with the 30 I use O'Connor as my main reference and I work the two, O'Connor and ALCHEM, together. In some places I use ALCHEM very heavily some places O'Connor quite heavily.

5. **Lantz:** Okay, well that gets us into the second question here. Are there any parts of ALCHEM which you omit?......demos, exercises? Just off the top of your head can you think of parts that you just leave out when you are working through the course?

6. **Allan:** The labs? I know one lab I do omit on purpose and that's the first one in Section B on nomenclature. I drop that lab it requires that students build models and draw, in essence structural formulas. I have tried it with my college group and I found it primarily just a waste of time because they haven't gotten into the structural formulas and you've got to take time to explain it and I think that building is more appropriate at the unit on bonding. For the nomenclature I build models and demonstrate that this is what they look like.

7. **Lantz:** Okay, yes, I think I know the one you mean. It does seem to come a little early. They are supposed to be constructing ball and spring models and they haven't done anything yet with bonding and have no notion as to shapes. So you just leave it out at that point, and the equivalent labs that come later on, like in Chem 20 and so on, do you do those?

8. **Allan:** I like that one on bonding where you get.... It's right at the very first, right after... there is a bit of introduction to stereochemistry and Lewis diagrams and structural formulas, shape diagrams and there is that one, I forget the number of it right off hand, it's in that unit of chemical bonding. I find that good. I like that whole unit on chemical bonding particularly there. But facing a time factor, the last time I was through it I omitted that entire section on molecular shapes - I went straight through the rule portion of it. I have the book here I can point out what number that was. I went straight across to a bit on the vesper rules for shapes and I illustrated

the shapes using the vesper rules and we did lab G1 and then went on, now this edition is an older edition it's in a different order. But I spent a little bit of time on the theory of covalent bonding, and then I jumped quite a section in there on molecular shapes and I find this a bit difficult to omit because I think it's good particularly when you get into the organic chemistry because students need to know that a chain is not a nice neat line, but follows that tetrahedral angle. And to omit shapes is difficult but to get through I found that I had to omit that optional section on stereochemistry.

9. **Lantz:** So one of the factors then in contributing to omitting parts of the ALCHEM is just the length of the course.

10. **Allan:** That is right, that's one aspect. I think the whole 10/20 program is too big I think there should be a 5 credit 10 and a 5 credit 20 and a 5 credit 30 to get an adequate level of courses in. I have omitted some of the labs in the past and (now) I am working more in. It is a matter of building materials together into kits so that you can pull a box off the shelf and here is all the little goodies that you need. I found that this was true - here is all my collection for Lab C1. We don't have teaching assistants here or lab technicians so it's up to the individual staff to prepare their own labs, and if you have got to go looking for these labs you spend an awful lot of time because you have 15 or 16 different stations to set up. It's not a matter of half a dozen solutions that everybody draws upon. You've got 16 stations and it's time consuming if you have got to round up all the different materials. They are good labs and I am working more of those in but I am going to have to set it up so that they are in boxes and when I come to Lab C1, there is the box and here is my ENO, and Drano and Saniflush and the whole bit, and I can set them out.

11. **Lantz:** Yes, I can see that being the case, the school that I used teach at has had lab assistants so we haven't had that problem. The first time through the lab assistant had to do a lot of work to get these set up, but once they were in place it was fairly straight forward. So a factor then from your point of view is just how much time it takes to set up some of these labs.

12. **Allan:** That is right, this is where the college has been good for me. We are working into the 10, last year was the first year we really used the 10. The year before was the first year we used the 20 in the ALCHEM materials completely. There of course, they have a lab assistant, I specify what lab I am going to do and she has all the materials and it is laid out. So I have tried labs that I haven't tried before and that I found out how good they are and I am working them back into my system here.

13. **Lantz:** These were labs from other materials?

14. **Allan:** No, these were ALCHEM labs. Because we are using the ALCHEM. This is the college prep program. These are students that are coming back to complete a high school degree and go on to college courses.

15. **Lantz:** Do you find using the ALCHEM with your 10/20/30's here and using it with the college prep program there are sort of different things that you need to use or you adapt a little differently for the two groups?

16. **Allan:** Oh, for sure. I think any high school chemistry course assumes that students have come in from grade 9 junior high science and they know what atoms are and what molecules are. Not in the detail that we are going into them but they start talking in grade 3 science about water molecules and how hydrocarbon burns and you get carbon dioxide in water they have encountered these things and you get these college students, particularly the older ones. I am talking (about) people who are 35-40. Well, at that time they didn't talk about atoms or molecules until high school and that's when they quit. So your talking about an atom, you're talking a foreign language - so I find that they get bombed with a lot of vocabulary that doesn't faze the high school student.

17. **Lantz:** Right. I would suppose that some of the parts of ALCHEM, the drill and

practice exercises, would become helpful in that case. I have sometimes felt that there was too much there - that it was a bit redundant, for a least good students that came from grade 9, and certainly by the time they got into grade 11 that they were doing things over and over that they had mastered. You don't have to do it I guess if you feel the class has mastered that part.

18. **Allan:** That's right you can be quite selective.

19. **Lantz:** In question three here, "Are there any parts of the ALCHEM which you supplement, films, additional notes, labs demos?" You already indicated that you use the O'Connor book and Keys to Chemistry in certain places. Can you think of what some of those places are?

20. **Allan:** Virtually all the way along. You know I take the ALCHEM as a skeleton set of material to work from - at places it's very good. I think in the nomenclature unit the notes are excellent and there is only the odd place that you need to point out some things. In the nomenclature section I find that I do supplement it with drill exercises. I noticed that while the students are expected to know large number of ions and how to use them, the exercises center around a few ions. There is an imbalance there so I tend to supplement that quite heavily with exercises. Elsewhere I find that the exercises are quite adequate and my main supplement is the core outline and I use my class to expand upon it, elaborate. And I for my own lesson part I draw upon any reading material that I come across. The first unit (in ALCHEM 10)... I have added in study questions there. I can give you copies if you are interested? (Lantz indicates interest.) To direct students just simply to do some reading, questions like, "We talked about an element. What is an element?" Make them go back and search through their materials. Certain questions force them to look over the periodic table and look for something on it. I have done some questions there - I have added and deleted and changed things around a little bit in that respect. So I suppose that that has been a main area that I have supplemented. I have written a number of things over the years and some cases I hand them out as supplementary materials for the ALCHEM, simply because I have had them prepared before and in other cases I have taken the time to write up some things. Some of it has become dated and it has got to be redone. But I have added (material), and I can give you copies of it. (Allan gave copies of these supplementary materials to Lantz. They are discussed in the third interview with Allan.)

21. **Lantz:** What about the area of films and that sort of thing. Are there any beyond the ones that ALCHEM recommends that you go on?

22. **Allan:** I have drawn on - I like that one, *Chemical Families*. I want to get a hold of the one on chemical bonding and I have trouble pinpointing down and saying this week I am going to be on chemical bonding and booking that film four months ahead of time. Some people manage to do that - they sit down the first of September and they will book all their films and how they decide what is going to come in and be useful I don't know. So I find that a problem - we have a good material resource centre for this area it's called, "ACRES". It happens to be that the office for Acres is in our county office so it's two blocks away and you can nip down very easily and get the films, but there is that booking problem. The other thing that I have found, at times, is a reaction I had a long time ago from students - I don't show films very often - but one student in the back said "oh no - not another film". And in some ways I think that the students would rather see a teacher fumble through a demonstration because you don't have the time to produce an artistic, perfect demonstration, talk about it, ask about it, see the things happening and smell the smoke or whatever that's coming off, rather then see it on a film. So a film I think is only good if it shows something that you can't do conveniently in the classroom. For example, I think this one on chemical families is good because it shows a whole flock of reactions that virtually are impossible to set up in a school system. I have not used films very much. I have relied on my drawer of tricks and if any body looked in it I think it would be a bunch of junk, as far as they are concerned, but it's what I have accumulated that shows different things.

23. **Lantz:** That certainly is a part of teaching, to accumulate a bag of tricks as it were, and maybe even things you picked up teaching a different course that work well. I am working with student teachers right now and one of the main areas where they are difficient is that the don't have a bag of tricks, and their reportoire is quite limited and that's where the experienced teacher has an advantage.

24. **Allan:** Well this is the thing that I find going into the (name omitted) College, I don't have my bag of tricks. It consists of a drawer, and my demonstration bench in the classroom. I need something - out comes that drawer and I pull out this, my models, or whatever, and when I get in there (referrin to the college) I either have to anticipate everything I need - anticipating all these things and carrying along in addition to my briefcase, a whole box of goodies or the other thing is a question comes up and it's really not something that you planned but by having your bag of tricks or immediate access to your lab or whatever, you nip out of the classroom for 30 seconds and pick it up, or pull open your drawer and say well here this illustrates what you were talking about or here is an example. And an inexperienced teacher or if you are moving out of a very close situation where you are working for a class, you just don't have that.

25. **Lantz:** Yes, that's right. And that's the advantage of having a room of your own where you don't have to move around and nobody else comes into to disturb you. In terms of adapting and modifying ALCHEM - we have talked about that - in response to the other two questions about omitting and supplementing - any other things that occur to you in terms of adapting and modifying?

26. **Allan:** I suppose most of my modification would come in terms of how I expand on a topic. Possibly a different way of explaining something. Now that I have my own pet way of doing something that I feel very familiar with I have modified and I see the latest editions of the ALCHEM have included it and that's using the mole, the 22.4 litres per mole concept. I had worked that in and I think this is actually a glaring omission in the ALCHEM is any reference to the gas laws. It is assumed that it's done in physics, but not everybody takes physics and so it needs to be included and a place has to be found for it. So that's one I suppose modification being partly taken care of. Stochiometry is another one, I do it my own way, and never thought much of it, but they were pointing out to me at the college that they find that limiting agents, where you have a stochiometric calculation where you put two kinds of substances in and which one sets the limits on how much product is going to be produced. There are no examples really of that type of thing.

27. **Lantz:** Thats right, it's assumed that they are there in stochimetric amounts or else it's clearly that one is in excess and you don't have to figure out which one.

28. **Allan:** You just assume that there is enough of all the other things to deal with what you are being asked about.

29. **Lantz:** Whatever the question is about it's all going to react. That's right and I found that that gets pretty difficult.... I mean at least for students that are in the introductory level... it's a tough concept for them. Because they end up sort of doing the question twice and see which one they have more moles of.

30. **Allan:** Well actually this comes with the developing of insight and I suppose what we call number sense that you don't have to go all the way in a calculation. There comes a point without going into all the details that you say obviously this is the limiting one and proceed from there without calculating it out to the nth degree. The other unit that I modify or the point I modify....Ah, equilibrium is introduced very briefly in the 20 level and I find it very difficult to deal with Ka's for acid without background in what an equilibrium constant is and so at the 30 level before I go into the section on Acids and Bases, I spend some time dealing with equilibrium a bit on Le Chatelier's principle of stresses. I get into reaction kinetics there a bit where we talk about reversibility of reactions and throw in a bit on activation energies . We do the experiment that's out of the - it's in O'Connor and it came out of the CHEM Study as well - about determining an equilibrium constant. That is the one with the iron (III) and

thiocyanate reaction. I do that and the experiment itself is not difficult and it does lead them into equilibrium constants and numerical aspect of the equilibrium constants and I find that at that point they have a terrible time dealing with calculating concentrations from successive dilutions. We actually get bogged down on that.

31. **Lantz**: There is a good opportunity there for teaching applications. that's something to really get into in Chem 20 but now here is a place to apply that.

32. **Allan**: It comes right back - this is when actual application is no longer a theoretical question - it's a must. I feel that about not being able to get into solubility products. Because I think that you could spend some time there. So that bothers me that that equilibrium unit's out and if I can get more of my organic chemistry shifted into the 20 which is hopefully going to happen this year I will have time to pick up an elective unit in grade 12 and spend more time on dealing with chemical equilibrium and reaction kinetics.

33. **Lantz**: What do you do now by way of electives?

34. **Allan**: In the 10/20 as a unit - nothing, because there is trouble getting through it. I suppose that most of the elective time is spent elaborating on topics. In grade 12 we pick up the bit on equilibrium that's extra. The Chem 30 actually has more time than there is in the other two and, I spend some time on nuclear chemistry as an elective unit. I play that one to a certain extent by ear. I think they should know what a nuclear reaction is, the notation that's used, what radioactivity is and at that point the elaboration depends on student interest.

35. **Lantz**: So the only formal elective that you use would be nuclear chemistry?

36. **Allan**: Well I suppose you could call that unit on equilibrium a formal elective

C. Second Interview with Mr. Allan, February 16, 1983

(The interview was conducted in Allan's office at Parkland C.H.S., during lunch hour.)

1. **Lantz:** I have a few questions from last time, maybe I'll just start out with those. I understood you to say that you use both *Keys to Chemistry* and *ALCHEM* with (Chemistry) 10 and 20. But now your students don't have to buy either of those. They are supplied by the rental system?

2. **Allan:** That's right.

3. **Lantz:** Okay, and it's similar with the Chemistry 30 it's the O'Connor and ALCHEM but again it's covered by the rental system.

4. **Allan:** That's right. The students don't purchase any of their textbooks here.

5. **Lantz:** Okay, well that's a good situation to be in and I guess you have a stock of the Keys and O'Connor books that you could use.

6. **Allan:** That's right - we do. As I say, we, well I opted for the Keys first because I like the idea of a textbook. But my opinion is it's very poorly put together overall and definitely very short on questions. So we started at the 20 level with the ALCHEM and moved down to the 10. And this year is the first year that I have asked for the booklets for the 30, working the two together.

7. **Lantz:** That's interesting because we had a book rental program at Earl Grey as well and we used to get a little bit of static from the administrators because they felt that that was very expensive to be buying these ALCHEM books all the time. Have you had any problem with that?

8. **Allan:** Not yet, I won't say we won't. No the board has been, actually I think, very well off financially. This is the first year that there could be problems in terms of money. I think over the years that they took advantages of chances to raise money and were able to do it gradually and kept you know on top of things as prices when up, rather then being faced with a catch-up situation like some areas were. So we have been okay so far. Things are going to be watched a lot closer and I don't know whether we will run into trouble or not.

9. **Lantz:** We used to always point out that the ALCHEM books were cheap enough so that if you compared them to a conventional textbook that was pro rated over, whatever, six semesters of use it would come out about the same. Now I was wondering since you are using both of them and will eventually have to replace O'Connor, that you might have some additional expenses that they might not be too keen on.

10. **Allan:** That is a possibility alright, I actually think that when you look at it, the ALCHEM is considerably more expensive - because at $4.00 a booklet in five semesters you have spent $20.00. Whereas these books (cost) probably... less than $20.00 and they run 10 and more semesters without too much trouble.

11. **Lantz:** I guess the figures that I was quoting there were ones for when ALCHEM first came out and it was about $2.00 a package then. That would be a problem with using materials that are depletable.

12. **Allan:** I don't know what the textbooks run but I am sure that they are under $20.00.

13. **Lantz:** I think they get close to that probably at face value. But then you get 40% discount. So it's down to $ 10 or $ 12.

14. **Allan:** So on that basis in three semesters your ALCHEM material costs what a textbook would cost. After that your textbook by comparison is pretty well free. That starts to add up substantially over time.

15. **Lantz:** That is going to be one of the problems with the ALCHEM format in the future. (pause) You mentioned that you had jotted some points down since last time - do you want to go through those now?

16. **Allan:** There's only two. There's a couple of others but I don't know if I can remember them - I didn't jot them down. I notice - you know I am right on nomenclature right now - with the College and here both, and in one place you use, for example, bisulfate and in another place hydrogen sulfate. I realize that you need to recognize bisulfate and bicarbonate one would think in terms of sodium bicarbonate you know that is the common lay term. I sort of have the question - why incorporate both?

17. **Lantz:** Okay, I don't know the context of that. I think we tried to get rid of all of the terms like bisulfate to be consistent with IUPAC nomenclature and it might be mentioned somewhere almost as a common name for sodium bicarbonate. I am surprised that it's used in a problem somewhere, used as a straight name.

18. **Allan:** Yes, I don't have a set of materials here - I would have to look on the periodic table. But I am sure that even on the back of your copy of the periodic table that that's how you list it. Well, you have listed it both ways. I have to stand corrected on that. But I do know that it comes in the questions and you do have ....

19. **Lantz:** Yes, they are both on there. Right, I think that the materials should indicate that the hydrogen sulfate is the preferred name.

20. **Allan:** Right, and there are some of the questions in the unit had used that. Since I was talking to you, I thought that I would draw that to your attention because it does come up. Well, here is a question for example it says what is the formula of sodium bicarbonate. I think, "fair enough it's a common name", but I wonder about it. And I could say the same about it for stannous fluoride being used, because that's the way it's used in the commercials rather then tin(II), but I wonder about cobaltous chloride instead of cobalt(II). It's not a common type of name. That was one thing that concerned me. And then, going through the exercise on nomenclature there is very little variety. That bothers me. If I take the pages B28 through B30 at the end, I would say HCl aqueous crops up about four times in their 90 questions. Ammonium nitrate, a very common compound, but it crops up enough times again that it's almost like a drill exercise to memorize those formulas rather then a drill exercise in which you learn to manipulate positive and negative ions. Simply as an exercise in naming and writing formulas. That bothers me and I know I resort to my own sheets here more and more because I will go down the list of ions and say alright these are the positive ions and these are the negative ions and simply make up as many different combinations as possible. Some of them I suppose actually are quite hypothetical in that they don't exist or at least not commonly.

21. **Lantz:** That was one of the concerns that we had that we always tried to write compounds that actually existed and the check on that was always... With those work sheets on nomenclature there is usually a use given for the substance, and if it something that doesn't exist then of course you can't come up with any use for it and so that's a limiting factor and it cuts down the number of possible combinations. We were trying to get at the idea of applied chemistry and we were focusing on compounds that not only existed but had a fairly common meaning. So that's probably why amonia nitrate and hydrochloric acid have come up so often there.

22. **Allan:** The possibility exists then maybe we should be, in the high school program, resricting the number of so-called common ions that we make use of. Limit it to fewer numbers because we don't (deal with that many). Most of the compounds we deal with are nitrates, a few sulfates, carbonates, and hydroxides.

23. **Lantz:** Yes, we could get by with fewer I expect.

24. **Allan:** That's right. I know one on your list is stearate... practical use?

25. **Lantz:** Bathtub ring is about the only one.

26. **Allan:** It is still a wild sort of a one to remember because it doesn't come up that often really and you know this is one concern that I had in connection with the nomenclature. Just the way that it's presented there.

27. **Lantz:** Okay, those are good points - I will keep those mind. I know the guiding sort of feature as we went through it was to focus on common compounds that had some application that the students might be able to identify with. We threw out a number of logical kinds of combinations that didn't seem to have any common use.

28. **Allan:** This is what it looks like. It narrows it down a bit, and I am not saying that's necessarily bad, but it does restrict what turns the materials themselves into the type of drill that they get. It is repetitious of the same kinds of compounds with the same ions and I think a person could end up almost remembering particular formulas of compounds easier then relating to the charges on the ions and the rules of putting them together whereas - so they have to know sodium ion and bicarbonate. Maybe there better be a strontium bicarbonate in their so that they know how to play around with strontium with something other then strontium nitrate and the same with bicarbonate or hydrogen carbonate with something other then sodium. When they come to apply the rules of formula writing more then being narrowed down to lets say eventually you get to memorize for something like sulphuric acid I say forget the rule - this is the stuff that s common enough that's one you should sort of tuck away in your mind and remember.

29. **Lantz:** Yes, there is a reason to say that you want to know how to manipulate the symbols apart from whether the compounds exist. The old CBA course, Chemical Bond Approach use to go even further and would manufacture in questions, synthetic ions... just W+ and X- and even the ions themselves didn't exist just to see if you would know how to fit them together and of course the compounds were completely hypothetical. There is a point there to that there is a formalism that you want the students to learn that goes beyond whether the compounds are actually in existence. One of the aspects of picking practical chemicals to work on is that sometimes the chemistry is fairly involved in a fairly commonly used substance that is a little harder to understand the chemistry. I guess the one that comes to mind is some of the solutions that are used now to absorb heat in solar houses. Actually it's magnesium sulfate, no it's Glauber's Salt, sodium sulfate and that's within the pale. You can do that at a Chem 10 level. You sort of have to know about waters of hydration and what is going on with that. I guess it's more of organic chemistry where to understand some common applied chemistry you would have to know quite a bit of organic chemistry.(pause) Were there any other points that you had?

30. **Allan:** Yes, in the materials you rely very heavily on formulas when you get into mole calculations. You have introduced a large letter *M* for molar mass, and in typewritten materials it's not too bad to indicate it in italicized or script form as distinct from ordinary writing. But from the student point of view I think it adds in an extra symbol that confuses it with the symbol for molarity. To use *n* for moles, that's fairly standard, but I found, and this goes back quite a number of years, that when I taught students to solve the problems by formula, or even to try and reason out - that we take sodium hydroxide, and you have got 25 grams of sodium hydroxide. How many moles do you have that you are trying to find? How many groups of 40 you have in 25? And I drew an analogy to eggs in a basket to find dozens, and to get them upside down. And I have switched over to a process that... People have different names for it, but it's called, "dimensional analysis" and in which you use conversion factors. One mole equals 40 grams or you could say take your 25 grams of sodium hydroxide and, "do I multiply it by one mole over 40 grams or 40 grams over one mole?" I want my dimensions to cancel out so that I am left wth moles I just don't automatically stick moles at the end because I know that that's what I am working for and punch some numbers into my calculator. I will take and check it right there if those dimensions don't line up the system is set up incorrectly. With a formula you tend to....I think, ignore that.

31. **Lantz:** That's right. You can still do that, of course. You can put the units on the numbers when you substitute into the formula, and then as a double check make sure that the units work out. What we used to encourage our students to do is to make sure that they had done the substitution correctly by checking on the units. However, what your suggesting is using this approach as a way of figuring out which number multiplies which and which divides into which.

32. **Allan:** That is right, and forget the formula at all, completely. It is a different approach. And I let my students last semester use the formula and I went along with it and see how things went. And you know it's in the materials there and so if they like, "Well here is a formula. "Well let's plug in". But I did see this cropping up, in questions like, "25 grams, how many moles?" Instead of dividing 25 by 40 they took 40 and divide by 25. Cancel out the units without really paying any attention to the fractions that they were actually working with and plugged in the unit on the end. I am pushing back this time around to use the dimensional analysis again as an approach. I noticed on dilution questions my grade 12's just went through a review unit in the ALCHEM that they were too quick to use initial concentration times initial volume equals final concentration times final volume instead of paying attention to concentration was total moles over total volume. You know that there is a principle involved there that they were missing. Plugging into a formula they missed the very obvious question. I had so many mills of so many molar solution that was diluted with 125 mL of water, what was the new concentration? Three quarters of them wiped out because they were not taking moles over total volume. They should have picked up that the final volume was the two added together. The other kind of situation that... You don't spend much time on it, but you put 50 mL of .5 molar HCl solution with 100 mL of .7 molar HCl solution what is the HCl concentration. Again, total moles over total volume. But the formula doesn't take care of it. So I think formulas have a place but you have to be careful when using formulas that you don't lose sight of the principle. We talk concentration to moles to litre of solution and we get very tied up in the formula of concentration equals moles over volume and really forget what that moles and volume really mean.

33. **Lantz:** When you are teaching this, do you sometimes use formulas that have the words in rather then the symbols? That's what I used to do before we came up with the capital *M* for molar mass. There would be, "number of moles equals mass divided by molar mass".

34. **Allan:** I am more inclined to write down words for equations. I don't do it when I do it on my own scrap paper or anything like that but I do on the board as I am talking. I find it a lot more useful because students will come and say, "where did you get that number from or I don't follow you", Whereas if you read all the moles of sodium from this source and all the moles of sodium hydroxide from that source, they could say, "Oh yes, we're taking this and we're taking that and you put them together". This is why I like your approach to your stochiometric calculations on equations. It's an approach I was using already. It is a logical sequence of events. I suppose it is a formula in a way, that you follow a very definite set of steps, but there is a pattern there that enables you to keep your ratios in the right order. It is completely adaptable to when you are talking about mass, particles, gas volume, concentration solutions it covers the whole works.

35. **Lantz:** That's right and it makes them moving on to the next type of stochiometry quite easy to do and pick up with what they have learned the first time to adapt it or expand it a little bit to cover molar heats or something.

36. **Allan:** That's right. It is a total pattern solution, it's a format rather then a formula that you have little slots that you stick numbers into. There is some additions that I have added in a little bit on the nomenclature on organic chemistry. In terms of the steps that you have for your rules, there was three things that I emphasized.

37. **Lantz:** You add some more steps, is that it?

38. **Allan:** Well it's implied in what you do. As I recall, I would have to look at it to be

exact, but when you are naming the positions of the attached groups the branched, numbering them, I emphasize the aspect of a number for each branch, is branch is located by number. In - I don't know if that's brought home specifically, it's implied but it is not brought home and I altered it a little bit when I pick the parent chain. It is not so much what is again the variation but a try to establish that there is apparent structure and everything is attached to that parent structure. That is your basic chain and I think that yours is all there. It's phrased a little differently to what I use. I expand some of the equations on the reactions of alkanes I find that it's short on explanation they need it supplemented. This was behind the nature of the design of the materials as far that goes so that's - I think that's all parcel of reason because they weren't designed to be complete unto themselves.

39. **Lantz:** That was the origin of ALCHEM.

40. **Allan:** I have expanded beyond what is required but even just limiting it to the kinds of reactions that you are looking at there I think it needs just a little bit more. I expand on the substitution reactions. There is going through this introducton of ALCHEM I realize that point I show a couple of others. Illustrate just a little bit more completely. That organic section is one you can add and add and add to. You have to be tremendously careful that you just don't get bogged down in one area and lose sight of the fact that you have a lot to do yet for the rest of the year, other then organic chemistry.

41. **Lantz:** Try to hold back from just going on and on. (Pause) I have never seen some of the things on the bulletin boards in the room. What is this, "Synergy" about? (refering to a poster)

42. **Allan:** That is connected with the science fair. The elementary school is doing quite a bit on the science fair this year. My son is involved in it. What I know is what you see in essence.

D. Third Interview with Mr. Allan, March 23, 1983

(The interview was conducted in Allan's office in Parkland C.H.S., during lunch hour.)

1. **Lantz:** The first thing that I would like to talk about are the handouts that you gave me last time. I am wondering what the function of these are and also, sort of, where they come from. That's the first one, it's called, "Introduction". How do you use that in chemistry?

2. **Allan:** Um, when I did this... There's always the question of, "What is chemistry?", and "Why should we study chemistry?". And it was given out with very little discussion actually, simply as an introduction to chemistry. Most of these kids well they've had some chemistry in Junior High. They are starting on what could be a minimum of a three year sequence of courses which is quite extensive and suggesting of some possibilities of where it might lead. Both in terms of general knowledge, what to expect from the course, and you know, possible careers.

3. **Lantz:** So you give it out in the beginning of Chemistry 10?

4. **Allan:** That's right.

5. **Lantz:** And ah, do you come back to it at all?

6. **Allan:** No, not really.

7. **Lantz:** Just hand it out and it is reading for the first day or two?

8. **Allan:** That's right.

9. **Lantz:** It looks to me like it is very well written and put together, did you find it some place?

10. **Allan:** No, that's mine.

11. **Lantz:** Hmm, good.

12. **Allan:** I looked in various places and collected information, but it is mine.

13. **Lantz:** It looks like a very good survey of chemistry and various branches of chemistry. Do you get students asking you about it? Like if somebody was interested in studying chemistry would they ask, you know, "What is physical chemistry?", that sort of thing?

14. **Allan:** I wouldn't say at any particular point. Those questions come up along the way in the course. What's going on here or where does that come or like ....

15. **Lantz:** So at some point do you refer back to it and say this is how it fits into this sheet I gave you on the first day. We are looking at organic chemistry now, which is....

16. **Allan:** Not intentionally, alluding back to it would happen because I have my own ways of attempting to relate what we do in the classroom to what might be going on outside the building. That's one aspect of it.

17. **Lantz:** This is, I guess, related to that (refering to a page which outlines reasons for taking chemistry). Does that go out the first day of class too?

18. **Allan:** Yes. In fact of the two I did this much before I ever did this. And so there is quite a span of time between the two. In fact I don't think the last little while I have even been using this first one. You know it's been hit and miss. Sometimes I do and sometimes I don't. This was another attempt to encourage students to take chemistry because a question comes up, "Why should I take chemistry?", and I try to

shut that one down before it ever crops up because it is not a question that I am really interested in flogging. You have your reasons and let's just lay it on the line. You are here for one of these reasons. My reason, that was one of the reasons... Another reason for writing it was brought about of course by this article on the bottom here 'words of warning' which I just forget exactly where I got it from now.

19. **Lantz:** It looks like it may be *Sciquest* or that *Chemistry* magazine.

20. **Allan:** *Sciquest* sounds like a good possibility. I was sorry to see that magazine discontinued. That's a good possibility. And the other (handout sheet) was prompted about because I am involved with PAL in a very minor way, it is the Preserve Agricultural Land Group, that was formed at the time of the (name omitted) plant being put up. And my comment here is that you can't afford to be scientifically illiterate because you are put under pressure by a lot of people that are smooth talkers and not necessarily very knowledgeable. It came to the point there the one meeting I was at they were squabbling over.... not squabbling, that's not a good way of putting it. There has been some controversy over the change in the soil Ph as a result of the Esso Plant that's east of (name omitted) there. And you get the two sides of it, one person saying that a Ph change or a soil change by a Ph of 1 that's a whole lot and the other that well it hasn't changed by 1 its only changed by .7 or .5 and its a very small change. At the meeting I pointed out, "What we are talking about here are Ph changes of 1 as a tenfold change in acidity of the soil, and a tenfold change from the midpoint of high productivity for agriculture. You change that by tenfold and that puts you into the marginal". I said, "Now whether the 1.0 or the .5 are correct or not, we can argue about that", but I said, "There is this small number that you are talking about is actually a very significant change". I alluded it to your paycheque. I said, 'you complain about a tenfold change in your taxes on your paycheck up or down'. And this is what I meant by being scientifically illiterate. These are farmers. They never knew that this was going to come about. So my point is you have to know something and chemistry is part of being a person in our society.

21. **Lantz:** Right, you know I think that document makes the point very well. There are a couple of things that caught my eye. One is the statement, "You cannot afford to be scientifically illiterate". The other one was this one here where you are talking about the value of chemistry for girls and for boys. Do you get any reaction from girls - women's libbers, who don't like to be referred to as doing the cooking and the cleaning while the boys do the more interesting things? Any response on that one?

22. **Allan:** Not really because if its discussed, you know, I say these are the common sorts of things. You know I play down the fact that I have mentioned traditionally the female (occupations). If it ever comes up its something that I squash. The significance of my use there is not to distinguish sexes its merely ideas.

23. **Lantz:** Those roles are probably accepted pretty much to here. I guess the reason that they caught my eye is that Dr. Kass is very much on a "women in science" kick and she has done a couple of presentations which I have heard, and so when I saw that statement it, sort of.... I was wondering if you got any feedback from the students when they read that?

24. **Allan:** No I don't, because you know a lot of the people at this level at any rate are not headed for science. Not that I am trying to discourage women from going into it. And that is partly the reason for over here that I say that these are very typically female oriented jobs as well as male and it is neither here nor there. The other thing that came out of this and I came across after is that one of the instructors that I was talking to at (name omitted) College, I have known him for quite a number of years, was commenting about this aspect of concern in the States and the fact that they are coming through now with a generation of high school students that are being taught their chemistry, or math, or physics in high school by teachers who had one physics or science class in high school went on to other levels of study and they are teaching, and somebody has to teach the sciences and somebody gets assigned the job. They are not anywhere near qualified and the article that he had read expressed

a great deal of concern over the fact that we're bringing up a whole generation of people that possibly wouldn't be able to handle the technology that we have developed at this point. The science oriented people are going into industry where the pay is better.

25. **Lantz:** Okay, so you mean at the secondary level that teaching of science is being done by people who aren't really trained properly. Is that what the article is saying?

26. **Allan:** That's right. You know I'm saying that their last science course virtually was one or two science courses in high school and they are expected to teach science courses at that level or higher. You know it is just a matter of fact that a person's interest in science is going where the money is and that is industry.

27. **Lantz:** Sure, although there has been a down turn in the industry, at least locally, and that may be only for a short time. That may send people back into education and think there are some signs of increasing university enrolments in science methods courses at university. They may be up partly because the people who have science degrees are not able to get jobs right now, so it looks a little bit more promising in education.

28. **Allan:** Well this was a U.S. situation. It wasn't a Canadian situation. You know the salaries, teacher salaries in Canada are a lot different from what they are in States.

29. **Lantz:** Yeah, right. These last two pages I think are sort of outlining how marks are given in the 10/20 and the other one is on lab rules. I guess the thing that caught my eye here was the comment about students who need help not letting it slide too long, and come and get help, well, right away. Do they do that, do they come before it's too late?

30. **Allan:** No they don't. There is a tremendous tendency to sit back and diddle your thumbs until, "Tomorrow there is going to be a test". Then, "Can I get some help?", and at that point I tend to be hard to get a hold of. It just ticks me right off that you will sit back and let a situation build. If there is a problem then we deal with it. You know if you're not concerned until the crunch is on... and so I emphasize that. The handout itself in terms of evaluation and that is a requirement that we have here that the students very early in the semester are supposed to be informed as to how they will be evaluated in the course.

31. **Lantz:** Yeah, that's what it was like at Earl Grey as well.

32. **Allan:** That fits that. The other.... was that all you had comments on? You had that one starred there. That's why I was wondering.

33. **Lantz:** Yeah, the other one about the lab, that describes the situation where they are given a station and also basic equipment signed out at the beginning of the year?

34. **Allan:** No, it's not signed out. We've got - our lab is set up with 16 working stations. I don't like to put all the material around because I find, you know, glassware and test tubes and that, gets put into drawers. It gets broken when it gets mixed with other things and it is put away dirty and all the rest but there is a certain amount of basic equipment that is pretty common and I attempted to make up a list and more or less keep it divided among the 16 stations. That was a convenience aspect because everybody uses that station. Each class that comes in uses it and it gradually gets mixed. That was the purpose there some general guidelines. In part I consulted with the principal too because we were going through a couple of dozen thermometers a year because students were using them as stirring rods, etc. It was rather interesting because as soon as we established that you could get billed for these if you used it for a stirring rod and smashed the bulb on the bottom, or if you let it roll off the desk because you didn't place it so it wouldn't roll. I mean accidents are accidents, but there are dumb things to do as well. Our breakage level dropped to three or four a year, and at three or four dollars a shot that is a substantial difference in cost. You know I forget it has been a couple of years since I ordered a

dozen thermometers. It has just altered the whole picture as far as cost. The other kind of glass ware we didn't have much in the way of breakage. The other as I emphasized you slide the bumper on a graduated cylinder down to the bottom and you bump it over and it smashes - tough. That bumper is suppose to be up at the top and that is what it is there for and I demonstrate this when we are naming equipment. I said, "knock one over and it bounces on the bumper and that's it". I said, "If something gets knocked off, bumped over and it falls into the sink and breaks, well that's a little different situation". But I have cut down the breakage there a bit too. So that was what that was about.

35. **Lantz:** Okay, If I can ask about how you use the elective component in the chemistry program. You mentioned that you do equilibrium and reaction rates in Chemistry 30 and that is technically elective material. If you look at the curriculum guide that you don't have to do that. Now why do you choose to do that as an elective?

36. **Allan:** Because of the use of equilibrium constants, your Ka's for acids are equilibrium constants. So I develop the idea of an equilibrium constant expression and manipulating that equilibrium constant expression and then went on to an application.

37. **Lantz:** Okay, so it's, sort of, to treat the acid-base chemistry rigorously you need the background in equilibrium. So that it s done to supplement?

38. **Allan:** That's right. Plus the fact I never really had any quarrel with the topics chosen for the Chem 30 program before. It was a little bit long but I thought it was a good selection of topics. Even the way it was from the CHEM Study. You know you can argue about the quality of the CHEM Study text, but the actual selection of topics was good. I was actually sorry to see the section on solubility products taken out.

39. **Lantz:** You think that is good from the point of view of what students are going to need at University, or NAIT, or SAIT?

40. **Allan:** The discussion on equilibrium?

41. **Lantz:** Yes.

42. **Allan:** Oh yes, I think equilibrium falls in there. In fact you've got a section on that in the ALCHEM 20, you know. That is, they are introduced to the equilibrium in a non-quantitative sense quite early and I add a little bit more on that just by way of mentioning Le Chatelier, and when I do equilibrium I work in the aspect of reversibility of reactions. That you've got that activated complex there, whatever it is, that is a question mark there, but basically if you can go over that energy barrier in the one way you can go over it in the other way. I have tried to explain why reactions are reversible a bit and then I do that one experiment where we develop equilibrium constant and the expression and ....

43. **Lantz:** In terms of the kind of chemistry that students need to understand social issues and concerns, the things you were talking about before like the soil acidity thing. Do you feel that equilibrium reaction rates gas laws that chemistry is useful in that sense too?

44. **Allan:** Not, I don't think in the same way. Those topics tend I think to be more oriented towards subsequent course that might come out.

45. **Lantz:** So its for a post-secondary course?

46. **Allan:** A lot of these students are taking Chemistry 30. By the time you get that far they are heading for some other place. It may not be necessarily a chemistry field but some of it requires chemistry as an entrance requirement. So you are dealing with a lot different groups than what you've got at the 10 level or even, mind you, by the time they get to the 20 level. Even they are pretty well oriented in an academic route.

47. **Lantz:** The ideas of the elective was to allow teachers to pursue, in some depth, a topic that might have social implications, if they wanted to. Like the ethylene plant, nuclear chem, that sort of thing. You can go in that direction and do a whole unit on it. But then you are sacrificing things like equilibrium reaction rates some of the traditional theoretical chemistry. That's the kind of trade-off that you have to make as a teacher. And you have elected to go with the traditional theoretical chemistry.

48. **Allan:** As it stand now. Now I think we may find coming next year where we can go on it for the first time because of our change in our chemistry 10 and 20 set up. Some of the organic chemistry done at the 20 level and I can see maybe a year from where we will have a major portion of it done that will free up some time in the 30. But up to this point because of the length of the 10 and 20 programs operating on an every other day basis, the organic chemistry never got touched at the 20 level. And it was done at the 30 level, and so that soaked up an awful lot of time. That organic section, to do it properly, I find is a four week course.

49. **Lantz:** That's every day?

50. **Allan:** Every day..80 minutes a day, four weeks. Now I think a person could push that through faster I think maybe where I could see you might bring it down to three weeks. But that is a heavy section. I got a stack of notes like this (indicating a thick pile of notes) by the time I've got that section done. It's as much work as two thirds of the rest of the course in terms of material.

51. **Lantz:** There is a lot of content there and then there are a lot of practical applications there too because so much of the commercial chemistry is organic in nature and there are so many places you can go for an example.

52. **Allan:** That's right and that never touches the dealing with the Alberta Gas Ethylene elective or anything like that. That's just that unit. Now which if you were to put it in the 20 level as a an every other day situation that's two months out of the five in the semester just on organic chemistry. Now that is a big unit. There's just not room.

53. **Lantz:** Now you mentioned additional notes that you add to what's in ALCHEM in the organic section?

54. **Allan:** Not a great deal, no. Not a great deal I have had to slice and slice and slice and .... just stick to the bare bones, ALCHEM.

55. **Lantz:** So what you do in your 10/20 course then is essentially in the two ALCHEM texts except the organic is put off to the 30?

56. **Allan:** Right. Well this year what we're going to have done is all of the 10. In the 20 booklet we won't do the review section because in essence going from 10 to 20 is a weekend in between. Now this year it is going to be over Easter. We will write the.... On March 31st they are going to write the Chemistry 10 final, and that means that when they come back from Easter they will know whether they are eligible for 20 or not, and we'll start on the 20. Which is the best ever managed as far as timing. Then we don't have to do the review section. Now I will expand a bit more on equations, possibly through worksheets and things, but I won't have to do any of the review section because they just finished it. There is no point in reviewing it they have written the final 10 days before so we will go straight into 20. So I have saved that whole time gap there and last semester I was able to get all of the ground work laid in the organic chemistry up through to the end of alkynes. And I can see where my schedule runs as well this time, I could conceivably even be further. But I will stop at that point because it gives me a common starting point towards the 30. But I can see where we will have chopped off two weeks of the organic chemistry out of the 30 level which should free up two weeks or better for something different in the 1983/84 school year for Chem 30. So I'll stick pick up the equilibrium section but something else to work in.

57. **Lantz:** You mentioned gas laws - at present you add gas laws to what's there?

58. **Allan:** That's a possibility, but no....

59. **Lantz:** That's something you talked about at the college but you don't ...

60. **Allan:** No, there has been no time for that, but that is one possibility.

61. **Lantz:** Can I just come back to the additional notes that you gave me last time? They were on the periodic table. There were some study questions on elements and a glossary of terms that was given out pretty much at the beginning of Chem 10. That's material that students are responsible for on tests, so that is really expanding on what's in the ALCHEM materials.

62. **Allan:** Right, I find that there are parts where it is a little sketchy on information, particularly in that first unit. There is just so much that you are starting from ground zero. And that first unit is what I think in part turned me off the ALCHEM because there wasn't.... It assumed lots, but there wasn't much there, and I think you need supplemental background material.

63. **Lantz:** Yeah there is certainly a lot that you can put into a beginning unit in chemistry by way of information on the elements how the periodic table was developed, some of the terms. Like - I know you have some in there like, "allotropy", and so on which belongs in the unit on elements, because of sulphur and ozone those are things I guess you've picked up partly from previous chemistry courses.

64. **Allan:** That's right. Wherever and whenever I've picked materials, and every so often as the course change I start all over fresh with a new collection of handouts extracting from previous handouts and my current reading and reorganize it to fit a new situation so that it changes.

65. **Lantz:** That's the beauty of experience you have that sort of thing to draw from.

66. **Allan:** That's right. You know it's tough on a beginning teacher, as good as the ALCHEM material is for structuring things. If you start out from scratch, you know, you've got to start digging all these things and its just that.... First year teaching without having to do all that other digging, and there is a lot of digging that has to be done. (It's) just a matter of knowing where to dig to begin with. So its ... that helps a lot.

67. **Lantz:** I had a few more questions here I think maybe I'll save those for next time. They had to do with what you call your, "own pet way of doing things". I was going to see what was behind that, but there is more here then what we can do in few minutes. Any comments that have come up in your mind as we've talked about these things today?

68. **Allan:** No, I think as they came up I said all I had to say.

E. Fourth Interview with Mr. Allan, April 14, 1983

(The interview was conducted in Allan's office at Parkland C.H.S., after school.)

1. **Lantz**: Yeah, I just wanted to finish up with some of the questions I had written out for last time. The time before you had talked about your own pet way of doing things and you had mentioned a few things that I jotted down and I got them again when I looked at the transcript. I just was interested in getting at a little bit of what function you think these things play in your teaching. Is it motivation, or some basic chemistry that the kids should understand, or helping them to form some basic concepts? Those kinds of reasons, I imagine, come in to play - but....

2. **Allan**: When I'm talking about my pet way of doing?....

3. **Lantz**: Well your bag of tricks let's say... um, you mentioned that you had this collection of odds and ends that you have available here which you don't really have at the college, so it presented a problem to demonstrate some things. With the little demonstrations that come out of that bag of tricks what sort of function does that play in your teaching as far as your concerned?

4. **Allan**: They come in to play, I suppose, as a result of the way the students respond to a particular situation. You know, somebody asks something and that immediately requires a certain kind of explanation and over a period of time you've put together a bunch of goodies. So that when the student asks a particular kind of question or has a particular kind of problem you can pull out some odds and sods that you can use to illustrate it.

5. **Lantz**: Can you give me an example. Maybe I'm not quite understanding.

6. **Allan**: Ah... I think in terms of... Physics, I suppose is one of the examples that comes most immediate to my mind. We're talking about when something is moving in a circle on the end of a string and you let it go it will take off in a straight line. You know, I happen to pull open my drawer and well I didn't have any string but I had a wire that had an alligator clip on the end of it that I'd use to hook to an electrochemical cell, well I took that and hooked a weight as.... I think I pulled an iron ring out of the drawer, clipped it on the end of it and swung it around and said, "Okay", You know, we let it go and it took off at a 90 degree angle or whatever direction it was heading. Its just a collection of things that.... You know, you get into an argument or discussion (and) you can pull something out that will illustrate it as a totally unplanned demonstration to a spontaneous question. So you need the things together. You can't pack that - you'd have to pack a whole drawer into a classroom if you were. You know, (if) your office and all your materials were in one place and you were teaching in somewhere else. I mean, I even run across into the hall - across over here, and somebody will say something and I say, "Well look just a minute". I can go and nip up and grab a beaker and grab something off the shelf and say, "okay -"

7. **Lantz**: Do these tend to be things that when the student is having trouble understanding a point or maybe is misunderstanding and these illustrations you've found to... to have clarified, to establish a concept or clarify the misconception?

8. **Allan**: That's right.

9. **Lantz**: That's the kind of.... That's one function of the bag of tricks?

10. **Allan**: I suppose in terms of this morning that(Allan's son enters the office) This is Mr. Lantz. This is my son, (name omitted).

11. **Lantz**: Hi. (The tape recorder is turned off for a few minutes while Allan talks to his son and arranges to meet him later.)

12. **Allan**: That the problem the students were having with that question (in the Chem 30

class). You know its something I hadn't anticipated, that they would have trouble calculating the amount of fuel needed to heat this up. And I drew an immediate analogy, I hope it was a close enough analogy, to taking a car down the road and how much gasoline do you need to put in the tank to get you a certain distance. Knowing your car consumes fuel at a certain rate. I'll tell you there was no - that analogy I pulled out that was quite original and I don't know if I'd say whether it fit or not.

13. **Lantz**: No, I think that it certainly fit in with the way that you were solving the problem on the board with ratios and in a logical sequence.

14. **Allan**: My bag of tricks in the drawer serves the same purpose.

15. **Lantz**: Okay. Sometimes I guess its function would be to present a model of a situation like - we don't do much with energy levels anymore but I guess that would be one thing where - we talk about electrons dropping from one energy level another. CHEM Study used to have this bookshelf with the different levels in it and that kind of thing would fit into that by way of illustration.

16. **Allan**: That's right. What was it yesterday?... We were into a discussion on where energy went. You know you had potential energy and, what was it? Stabilizing process, I know, it was when bonds form. I said if bonds are going to stabilize or form and the atoms are going to stabilize I said they have to lose energy. If they are going to stick together, you know, two atoms if they don't lose energy they approach they hit that repulsive force and it throws them apart. I took the analogy and I reached in my drawer and I pulled out...I've got a steel ball in there that I've used for friction experiments, and a tennis ball, and I dropped the two and I said the steel ball essentially hit the floor they stuck together and how did they manage to do that where this other ball bounced. Well somebody said energy loss and somebody else said well the steel ball is heavier so it won't bounce as high. So I went back to my drawer and I pulled out a styrofoam ball and I dropped the styrofoam ball and the rubber ball and I said okay the rubber ball is heavier and it bounced further, what happened? Well somebody said, "elasticity", and then somebody said, "well the one lost its energy the other compressed it and retained it and they bounced apart".

17. **Lantz**: Okay, I'm glad I asked because I had a little different picture of what you meant by that. I was thinking of a little strip of magnesium ribbon that you might burn to illustrate a type of reaction and maybe some reagent bottles for showing some typical reactions. Is that part of the bag of tricks?

18. **Allan**: That's part of the bag of tricks, that happens to be around the corner in the lab, I'll have some left over solution from an experiment. The question will come up and I'll end up pulling some left over solution or two or three of them a handful of beakers and my jug of distilled water

19. **Lantz**: And illustrate percipitation or that kind of ...

20. **Allan**: That's right, there is something that comes up. So that's part of the bag of tricks too, its just that it's ten steps across the hall it's not a five minute walk to the other end of the building or anything like that. Your perception there is correct.

21. **Lantz**: Okay, one thing I've noticed today and the other time as I sat in your class, is that when you have students put work on the board you make them find their own mistake. You tell them that's not right - what's the matter with it. That seems like a good practice and every time I've been here they've been able to do that. And that's the standard practice and the reason being....

22. **Allan**: Well I like to do them a bit of searching on their own because I'd like them to say okay you've made a mistake come back up here and let's go to work on it again, look for a fault. At a point I'll come along and I'll discuss it with them because I look at a student going to the board. They put a question on and they've got no trouble, fine go sit down and you've got the satisfaction that the job is good. On the other hand, as I go down the board, I will - when I discuss a question I sometimes have

them put their names on - other times I'll look at a question and I'll turn around and I'll say, "Okay, well, who am I talking to?" You know, "who did this question", and so somebody will stick up their hand and I'll talk to that person about their question and we will have a discussion. I expect everybody else to be listening and sometimes you have trouble getting this message across but it is something that I do with all my classes that I talk to that person and I consider them - they volunteered so this is their individual help session the rest of you can listen to what we are doing - we're through you can ask about it or take part in that conversation but I like to address that student. I suppose it's an idea I picked up from my wife actually. When she marks her kids workbooks, this is elementary grade 1 and 2. She will go down a page and she will put up at the top of it, "Five Wrong", or, "Three Wrong", where they have a little drill exercise. She hands the book back and she expects them to go through and find it. And they make some corrections, and they may make the corrections and come back and if they've got seven wrong because they've corrected already correct ones and made them wrong. This is her style of teaching, so I'm not sure whether I did the original on my own a bit or I picked this up from her. She carries it one step further. "Now if you know what the idea is go fix your mistake".

23. **Lantz**: Okay, and this came through also in the problem session today about not using the formula for molar heat. What we were talking about a minute ago that the ALCHEM examples are worked out in a very set way always the same, using the same formulas and steps, and the students who are following this, to some extent, but when they were having trouble and you were explaining it or adding on to it you were getting them to really reason it out from sort of first principles - I don't know a ratio idea and um ...

24. **Allan**: I know, there is some, and you get very good students they want it to be right and they want it cut and dried. While that particular set of problems there you're dealing with real life situations and there isn't a formula there. No you've got to - sure this little part can be solved with a formula, but you have to analyze a total picture and apply some logic to it.

25. **Lantz**: Yeah, I thought you were being very careful to work up a method there. Analysing the whole thing, putting it together, drawing it out. I thought that was a really effective lesson in problem-solving.

26. **Allan**: I hope so I'd have a terrible time teaching problem-solving. You know I can show somebody how to do it. I can lead someone through, but to say, you know, "These are the steps to logically approach..." That's a weakness I have.

27. **Lantz**: It's hard to teach. There's no doubt about it.

28. **Allan**: It's crucial, I think it's probably more crucial to getting an education that you learn how to learn rather then maybe learn chemistry or physics or anything else. Most of what maybe these kids will ever carry out of school on a long term basis that would be of most value is learning how to learn. That's problem-solving techniques where they can know how to approach a new topic and learn it.

29. **Lantz**: You had mentioned that you don't care to use films very much, or you don't use films a great deal and it occurred to me I wondered if the reason was is that students are sometimes skeptical about things that they see in films. I'm thinking particularly of ones where there are chemical reactions done and, you know, you can fake things on films. You see all of the special effects in the movies now where if you see it done by the teacher in the room you're more convinced that it really does act that way. Sodium really does react with water and that's not just a fake thing. Do you think there is an element of that?

30. **Allan**: It's an angle that I haven't thought of. I do know that in many cases a student would prefer to see you fumble through something, and they get to talk about it while you're doing it and they see the smoke rise and smell it and all the rest and the class squirms and maybe I've got to go open a window to let everything out. They do find that more interesting than films. (tape recorder turned off while Allan

answers a phone call) I used experiment 26. I think it is from the O'Connor approach, it is very much like your ALCHEM one, and it is the one where you develop the law of additivity of heat.

31. **Lantz**: Oh yeah, that's the one that students were handing in?

32. **Allan**: This is the one where they actually apply it. This one was 27. They put - this is where they calculate the heat of reaction for a particular reaction by observing the heats for a couple of other reactions and then they have to put that together to come up with conclusion for a third reaction. The one taught before that is they put sodium hydroxide in water and they calculate the heat given off from that. The next one they do is they take a hydrochloric acid solution and a sodium hydroxide solution and determine the heat for that one. And the third reaction they do is put sodium hydroxide solid into hydrochloric acid solution. Of course that last one is the sum of the first two and so you should be able to take the heat from the first two reactions and get the delta H for the third reaction. Most of the time, well I have done it dozen of times with classes, and well you get the odd student that's got a 30 or 40% error and that most times they'll get the data processed right. There's always 2 or 3% error. I mean their agreement is very high and that's just working with the styrofoam cup calorimeter, too. Most of them under 10% and it's close enough to say, "Look you know you made a mistake in your calculations so go clean that up". It does show a pretty high degree of correlation here. Now had you used a bomb calorimeter, you would have refined it one step further, this is what you would have got. But collectively, as a class, the experimetal error ran 90 to 100%. I have no idea what went wrong. I said, "Look...." They said, "What went wrong?" I said, "I don't know". I went on and said, "Look, you're going to have to face the fact that what you're going to do experiments you're going to have results that you've completely bombed", and I said, "Ideally we should go back in the lab and redo it and find out what went wrong". Maybe in redoing it, it is all going to work out and we'll never find out what went wrong. But I said, "If that is the only experiment that you ever do in the rest of your learning career in the sciences where you get a set of results that you completely bomb on, you're very fortunate". I said, "Because life just doesn't work that way". So I said, "It blew, I don't have an answer". I've got all the solutions and everything set aside. I want to go in and see if I end up doing it the same, having the same error. Which would suggest that maybe I made a mistake on the solutions. And find out - you know I said that's all part of the game.

F. Fifth Interview with Mr. Allan, April 21, 1983

(The interview was conducted in Allan's office at Parkland C.H.S., during lunch hour.)

1. **Lantz:** Yeah, the student opinion survey that your classes wrote last week, consisted of having them rate different aspects of the ALCHEM materials on a five point scale, where one was the low end and five was the high end, and those were on computer optically scored sheets. So I took them in and ran them through the optical scanner, at the University, and it came back with this kind of an analysis. Where it gives a mean rating for each item, what the average is of how the students rated it and then it gives a standard deviation. Now a standard deviation is interesting here because it's a measure of how spread out the students opinions are. If they all agreed on the rating if they all gave it a three and then the standard deviation would be zero. I think the maximum standard deviation would occur if half of them were at one end of the scale and half at the other. In which case I think the maximum standard deviation would be two. So we get some sense then from the mean and the standard deviation as to what the students think of it and whether they're agreed in their opinion. Well you can't see too much from that except that it also gives the break down as to how many gave each response on a percentage breakdown. This doesn't say what the question was so I'll have to give you a copy of this.

2. **Allan:** Right, I had looked through the questions at the time, but needless to say I've forgotten what the questions were.

3. **Lantz:** You can keep a copy of each of these so that you can look at them when you have some more time. Now I did a further analysis that we can look at now because it makes a little more sense than that overall one. I think you'll find it interesting information as to what the students were saying. Look at the ALCHEM 10 first. There were essentially three questions: "Is it useful for helping you gain understanding of chemistry?", "For preparing for exams?", and then, "Is it interesting?" So what I did was to take the ratings the students gave and ran it through a sort program that is on the university computer. So they rank then from the highest to the lowest. So in terms of gaining an understanding of chemistry these are the things that the students think were most useful from highest to lowest. The periodic table that is provided was the most useful thing as far as they were concerned they gave it an average rating of 4.8 and they're pretty much agreed on that. Then it goes down the list there you can just have a look at it and see if there are any surprises there.

4. **Allan:** I'm not surprised at the periodic table because you know every time you turn around you're drawing information off it. There's a lot of information the way that it's put together.

5. **Lantz:** And I suppose that the trends that you're trying to get across, particularly in the Chem 10 course, show up there pretty well. (long pause)

6. **Allan:** I'm surprised at this one - objective lists at the beginning of each unit because in actual fact I never emphasized those at all.

7. **Lantz:** Yeah and they got a pretty low rating though because it comes near the bottom. They gave it sort of middle of the road. There's some divisions of opinion there though. They're not all agreed about that. The biographical sketches now come in quite low.

8. **Allan:** I never spent any time on that - they were there for interest I figured, you know. So I left them at that - if there is something about the fellow go ahead and read it. But I never......

9. **Lantz:** You never brought it into the class or certainly not test - oh I guess that will show up in the next one.

10. **Allan:** No. Lab and safety?

11. **Lantz:** Did you work through that one at all. It comes - it's in the new course and it's

12. **Allan:** It's right at the... "lab on safety and efficiency", probably not....

13. **Lantz:** It's in the newer booklets I think.

14. **Allan:** There is that first section there where you go into the lab and you know it asks where the safety station is.

15. **Lantz:** Yeah that's the one, that's what I was referring to.

16. **Allan:** Alright, they may not even have separated that out as a separate lab. While I did use it, we went in - I went into the lab and we did organize the lab and named chemical pieces of apparatus and so on and it was all part and parcel of that that provided one segment of approximately two labs. So it wasn't emphasized as a separate thing.

17. **Lantz:** I gave an example of it so they would know what I was talking about there. Now that's the second one about what helps to prepare for exams. That's not too surprising the highest thing out of the worksheets that they've gone through in class. (long pause while Allan studies the SOS summary)

18. **Allan:** Yeah I'm not surprised again. You know the order is very similar. Two or three change places but....

19. **Lantz:** That's right. Now biographical sketches come in near the bottom because you just said you don't stress it. It doesn't appear on tests so they wouldn't see that as important. So that's kind of validity check as far as their ratings are concerned.

20. **Allan:** One I did use. There are certain people (who) discovered certain things that were quite significant. I brought this out but I didn't go into the biographical sketches as such I just extracted. You know well we're talking about Mendeleev, not too much about him but more about his accomplishment on the periodic table so ......

21. **Lantz:** To give credit to who discovered it. Now this is a little different this is whether or not they just find it interesting. That order might be somewhat different.

22. **Allan:** That one on chemical families rates right at the bottom.

23. **Lantz:** Yeah I was interested in that because they have all seen it.

24. **Allan:** I'm wondering now, just a second - they have seen but they saw it last week. Yes, last week

25. **Lantz:** Okay, so it was after I gave the questionnaire?

26. **Allan:** Hm, hm, that's something that maybe you want to note that we did look at on Friday. That's exactly what I did Friday, I said - I had it in for another class and I said this is one you need to see and I had one in, a film in, for my Science 11 and I said nobody wants to work this afternoon anyway - I said I've got to look at this film before the Science 11. I said let's see what it's about. So they never saw it. They never did the worksheet because of course they didn't have that booklet with them we're into the 20. We just viewed it for information.

27. **Lantz:** Okay that's interesting. I was wondering how they would rate it if they had in fact hadn't done it. It looks like they rate it low which makes sense because its not of much use to them, or its not very interesting if they haven't done it.

28. **Allan:** I'm wondering - this makes me wonder about this worksheet on chemical families rated a three. I mean it should have been, as far as they were concerned rated useless because they never did it.

29. **Lantz:** Right, now that's a problem - they probably didn't know what to do with a question like that. There should have been a category which said we didn't do this or something to that effect.

30. **Allan:** Well you got no response.

31. **Lantz:** That's true, they could have left it blank. I guess when I give this again I should just tell the students, "If there is something listed here that you've never used, just leave it blank".

32. **Allan:** That's right. That might be more accurate in terms of your survey. Because obviously any sort of rating at all on this would not apply.

33. **Lantz:** That's right. Not applicable.

34. **Allan:** You could even on... well... you know... well your survey is well under way now - but like you say a category six didn't do.

35. **Lantz:** Okay this is the first place that I've used it but I guess I think the best thing for me to do is probably just to instruct the students when I give it that if there are things like a film that they haven't done to just leave it blank and I can pick up those as the ones - because there may be students who in fact miss that day and don't know what it is about so they would ...

36. **Allan:** That's right. That would help with the nature of your survey.

37. **Lantz:** Interpreting the data.

38. **Allan:** That's right because any evaluation here the fact that its rated number 12 is or even 14 doesn't mean anything.

39. **Lantz:** I was wondering about what would happen if that sort of thing occurred and it looks like it tends to get a low rating. But for a lot of people they don't know what to make of it. I noticed that with the biographies they rate a little higher and here is a pretty high standard deviation 1.5 so I would guess that there is a division of opinion there that some students find it quite interesting. You know they read it on their own. Some students probably find it quite interesting and some quite, quite boring.

40. **Allan:** That's right it would be the difference between the boring in the sense that they don't particularly care for that kind of thing and simply didn't do it versus but find biographies interesting and read it. I bet its bimodal almost isn't it?

41. **Lantz:** Well its spread out - there's 25% at the very bottom and then almost evenly split but...about 13, 21, 21, 21 for the rest.

42. **Allan:** It does because the number 2 is very low and then average to interesting

43. **Lantz:** We're talking 24 students here so 21% is around the five mark, 4 or 5 students. So they're quite spread out there as far as whether they found it interesting or not I guess just whether historical human history kinds of things interest them or not.

44. **Allan:** I think that would be an accurate interpretation of that alright.

45. **Lantz:** Anything there on the 10's - now what I was going to do - I made an overhead transparency and I thought when I went into the class I would put it up and just explain what the numbers meant and go through and see if they had anything additional to add to that.

46. **Allan:** Interesting where they've rated demonstrations at. Under here, "gaining and understanding", they rated them at 4.0. It's a pretty fair high degree of consistency. You wouldn't know what number that is would you? It's alright. (Allan finds the

numbers himself) Demonstrations 19, 20 and 21. They've rated 42%. 19 was useful in gaining understanding of chemistry. You know there is only four percent that rated at 2.0, a quarter of them figured at average (3.0) and 42 percent were higher, so that suggests that my demonstrations aren't a washout anyway. And they rated actually 33% rated them as useful in preparing for exams and 21 interesting. That's an indication there of something. Information about sources and uses of chemicals - that's a hit and miss topic with them you know it depends on ... its one of those things that I tend to leave and say look here is a list of information I'm not going to stand up here and read off this list for you.

47. **Lantz:** So they're left pretty much to pursue it according to their own interests?

48. **Allan:** That's right and of course they rated it fairly high as interesting information and activity, information about sources and chemicals that was rated at 3.8 they do find it interesting. Which is good. I don't emphasize it in preparaion for an exam because it's one of those.... I think of it as an interest factor rather than an understanding factor. And of course that's bit consistent there where they rated as far as exam preparation. They do rate, um.... they *don't* rate demonstrations very high which can be harmful because quite often I'll make a point of asking them something about what we discussed in class or done (in class). For no other reason than you better be paying attenton because everything we do is important.

49. **Lantz:** Especially I think with your emphasize on lab equipment means, some of those things because those are essentially demonstrated to the class and you do that. Yeah there is a similar sheet then for the Chem 30s. They probably are remembering things from last year and as much as they've done this year.

50. **Allan:** That's right because what we did use the organic section very heavily and we were using the one on energy changes, chemical reactions. Primarily as a supplement to the text well I use the two of them side by side for questions actually so they would answer that. Now they don't rate the periodic table as high. It comes in third, for exam preparation its rated high, they find lab work interesting that's good because there is a fair bit more in Chem 30. Periodic table was down as far as interesting activity of course is simply a data sheet to them at this point. So it rates in the same category as ALCHEM data sheet. Review of chemistry 10 and 20 obviously not interesting, that's no surprise. Found review exercises useful for gaining understanding. Well that's true. Worked out examples and worksheets rate high in both understanding and exam preparation and that's no surprise either.

51. **Lantz:** Yeah, they seem to appreciate that aspect of ALCHEM as the exercise sheets or the practice kind of things.

52. **Allan:** There's lots of work there. Well I think most like the drill aspect because they don't like getting caught short on questions. There's almost too much there.

53. **Lantz:** Yeah there is and of course it doesn't all have to be done but you need to select what is to be done.

54. **Allan:** They don't think too much of my demonstrations, of course there haven't been that many. Oh well 3.6 is still not a bad rating. Demonstrations for exam preparation 2.6 now a demonstration illustrates the understanding and once you've got the understanding its almost difficult to separate these two. Well they'll maybe feel a little different about the lab work after the test they just wrote for me yesterday. I made an example of it I'll give you a copy of it - I pulled an example right off the data sheet on hydrocarbon combustion only I made up a fictitous one and I ran her down the whole sequence. But this would come out - lets see you gave this last week so they may feel a whole bunch different about that question today as compared to last week because the labs we had done on the organic sections of course were more of an interest nature whereas the ones we just did that was developed in the law of addivity of heats. It's a whole different kind of lab you know the one they did in organic chemistry we did a fractional distillation. We spent a day or two setting up fractional distillation equipment and so on which they

probably would have found very interesting as a procedure but not a great deal in understanding organic chemistry versus the ones on heats reaction. Molar heat of combustion and the law of additivity on heats was a direct lead up to a principle so they may at this point rate that substantially different.

55. **Lantz:** Now I was going to ask you about that. Do you require a full scale written up lab report?

56. **Allan:** No I don't.

57. **Lantz:** Oh, the ones that were being turned in last week what sort of format were they in?

58. **Allan:** They were in a worksheet form. I find that I spend too much time marking. I'm using the one out of O'Connor rather then the ALCHEM because that's the kind of thing I've got laid out.

59. **Lantz:** So it's a sheet to put your data down on.

60. **Allan:** That's right. You can take that one with you. See this is what I've done with this one too. I have laid out very specific spots for them to put their data on and then I've constructed a table that suggested they construct - the numbers here correspond to the numbers in the lab manual plus a question I've added. I find that I can mark this a lot faster. Now something like this I try to time it so that they do it finish it on one day I can take it home that night and mark it because the end conclusion here is the law of additivity of heats. I can fire this back to them the next day discuss the experiment and in the process of discussing the experiment complete the development of the law of additivity of heats as I expect them to understand it as one continuous lesson. So I have to have that turn around. If I'm going to read an experiment where they have done procedure and written it all up in the past perfect tense as a formal lab should be and on and on and on that's like marking essays. I don't think that it hurts that they do this I don't I can't make that turn around in time. I can't mark 30 labs (that fast).

61. **Lantz:** When there's a teaching advantage that you lose when (it takes too long to get the labs back to the student), sure.

62. **Allan:** Well I like to make a turn around on a test or an assignment or anything. Turn it in today I'll have it back to you tomorrow.

63. **Lantz:** I think that is a very good idea - students are much more motivated to benefit from their mistakes if its still fresh.

64. **Allan:** Well there is that aspect of it. They also learn a lot better, also there is no chance for procrastinating - I'm not going to accept an assignment after I've passed back the marked copies and taken it up. So you darned well better have it in. Now if you happen to be in the hospital sick or something like that, well okay. We'll either delete that assignment as far as your mark is concerned and treat it as it never existed, or come up with an alternative exercise for an equal number of marks. But I like to have that turn around in that in order to achieve that with the test that the students wrote yesterday we marked it in class today because I just didn't have time to mark 30 long tests last night. The student that missed yesterday was in a different room writing it - he missed the opportunity of taking up the questions any re-teach aspects that may come up as a part of not understanding things. But that's what I do with my labs I have steered primarily away from formal lab write ups.

65. **Lantz:** That's mainly because of the time it takes to mark them?

66. **Allan:** That's right.

67. **Lantz:** You feel that the teaching return or the teaching payoff isn't worth the extra effort you have to put in.

68. **Allan:** No I don't think so, I feel that part of learning is, I *teach* you *do;* I evaluate, you find out how you've done and then we discuss it. Its got to be an exchange. That's where correspondence courses and things lose out. There's a two way deal and the only way you find out if you know something is immediate evaluation on work. It's like taking a book out doing a question and turning to the back to see if you got the right answer - there is immediate feedback on an exercise from teaching. You got it wrong okay where did I go wrong - find out. If you got it right a pat on the back and away you go for the next question.

69. **Lantz:** Again that's the whole success of programmed learning or some of the computer assisted instruction they work on that immediate feedback.

70. **Allan:** Immediate feedback - not necessarily an interesting feedback but the satisfaction of saying I did that one right. I know how to do that question now. Whether I can do the next question of the same type correctly or not or if you change the words around you know that's a different deal. I think from psychologists what they claim that on a test that after about four days the feedback is virtually zero as far as reinforcement. It drops off really sharply. I don't know what the exact figures are but its not too bad on 24 hours, 48 and then it drops a long ways and then there's a level out spot somewhere down there for a variety of reasons. You forget what you've done so it means going back in detail to find out if you've done it incorrectly to find out even what you've done. If you've done it right you tend to have forgotten what you've done other then to say, "Well gee, I did that right". But you don't know what you've done right too clearly, and the next day that aspect is still quite fresh in your mind. I think as time goes by the importance of that particular exercise diminishes from an interest point of view. As the interest drops off the value of it, other then a mark you can put it your book and say, "Johnny did such and such on this activity", doesn't mean too much. I think especially it runs down to a couple of weeks, I really think that.

71. **Lantz:** That's right and that has to be the trade off I guess with any kind of exam or exercise or assignment you give the student getting it back to them in time has to be weighed against just how long and how involved the process is for the student. I know some people would criticize the ALCHEM because of the workbooks or the format. (They claim) there is too much of that sort of thing (in the ALCHEM materials). And that may be so, but a lot of the motivation for that was the very thing that you were mentioning. That you get immediate feedback and its easy to handle. A sort of, "teacher oriented", materials.

72. **Allan:** Well you also said that the original intent of the ALCHEM was to provide a large number of exercises, it wasn't intended to be a course in itself so much as activities and things to support the course.

73. **Lantz:** That's right and it has gradually filled in more of textual materials and labs. I think in the next revision you'll probably get quite a lot more of that sort of thing.

APPENDIX H

A. Observation Notes from Rutherford High School

The School

-brick and concrete building constructed in the mid 1950's.
-the building is still in good repair after 25 years of use.
-teachers and students take no notice of me in the hallways. (Outsiders, such as student teachers, faculty consultants, substitute teachers, and researchers are frequent visitors to the school.)
-The Assistant Principal (AP) in charge of the science program gave the following information on the community and school:
    -1982/83 enrollment was approx 1600.
    -students come from a wide range of socio-economic backgrounds, with many from affluent families.
    -Rutherford's first Principal established a tradition of high academic standards which has continued to the present.
    -considerable parental pressure on students to enroll in an academic program.
    -considerable parental concern over student achievement.

The Program

-AP gave me a copy of Rutherford's "Programs" booklet which includes the following information:
    -requirements for general H.S. diploma and matriculation programs.
    -an outline of the International Baccalaueate (IB) program.
    -a description of each course offered by the school.
    -information on entrance requirements for NAIT and U of A.
-AP gave the following approximate figures on the science course enrollments:
    -Biol 10/20/30=550/300/300.
    -Chem 10/20/30=500/410/300.
    -Phys 10/20/30=300/240/150.
    -Science 11=100.
-met with Assistant Department Head (ADH).
    -verified enrollment figure given by AP.
    -ADH coordinates the chem program in the school, since DH is a biology teacher.
    -chem teachers in the school share a common pool of extra worksheets and exams. (Maintaining this stockpile is part of job of ADH.)
    -ADH teaches part of the IB chem program.

Classroom Setting

1. Main Features:
-classroom on the first floor of the school.
-approx. 6 m X 6 m, 4 tiers.
-door beside front blackboard leads directly into a chem lab. (Jensen's lab coat hangs on the back of the door.)

2. Windows(W):
-along left wall, top half glass block, looks out onto parking lot, equipped with blackout curtains.

3. Blackboards(Bb):
-green boards along front and right walls.
-HW assignments for Chem 30, Chem 10, and Phys 10 written on the side Bb.
-notice about CBC radio program "Quirks and Quarks" written on side Bb.

4. Tackboards(Tb):
-small Tb on either side of front Bb.
-large Tb along back of room.

5. AV Equipment(AV):
-permanently mounted screen above Bb.

6. Special Equipment(Sp):
-equipment for "singing hydrogen" (coffee can with small hole in it).
-assorted colored chalk, brushes, and a Bb protractor along the side of the room.
(The classroom is also used for teaching Physics 10.)
-ring stand, test tube rack and assorted beakers beside sink on demo desk.

7. Shelves and Cupboards(S/C):
-shelves with sliding glass doors on both sides of room, used to store periodic tables and data sheets.

8. Wall Charts:
-ALCHEM periodic table mounted above Bb at front of room.
-ALCHEM data sheets mounted on tackboard at the back of room.

9. Posters:
-series of posters on "chemistry in service of man" along top of side Bb.
-posters on metrication from Toronto Dominion Bank.
-poster advertising CBC program, "Nature of Things".
-numerous "bumper sticker" posters, e.g.,
  -"a mole is a chemist's best friend".
  -"absolute relationships are attained by degrees".
  -"warning! I have a low activation energy".

10.Desks:
-student desks are separate, movable, sloping top, no side arm.
-teacher's desk at end of a demonstration desk at front of room.

11.Clippings:
-"Herman" cartoon on Tb at front of room.
-no newspaper or magazine articles.

12.Teachers' Office:
-located in prep room between chem lab and ADH's classroom and is shared by Jensen and ADH.
-contains two desks, two file cabinets, and shelves for storing supplementary Chem 30 work sheets.
-as this office is rather cramped, Jensen also uses the science workroom, and staff common room for preparing lessons and marking exams.

Teaching Strategies

Classes Observed
-Chem 10 class on review of bonding and nomenclature (Feb. 22).
-Chem 30 class on heats of reaction (Feb. 22).
-Chem 30 class on electrochemistry (Apr. 13).
-Chem 30 class on pH calculations (May 5).

1. Teacher Activity:

(Chem 10, Feb. 22)
-worked example at Bb, helped students individually as they studied for a test, told the students that the theory questions would be multiple choice but they would have to write out names and formulas.

(Chem 30, Feb. 22)
-reviewed heats of formation, developed Hess's Law, worked out examples at the Bb, demonstrated combustion of sucrose potassium chlorate mixture.

(Chem 30, Apr. 13)
-worked out electrochemistry examples at the Bb, helped students individually with assigned work.

(Chem 30, May 5)
-explained the pH scale, worked out examples of "type problems" for pH calculations at the Bb, helped students individually with assigned work.

2. Student Activity:

(Chem 10, Feb. 22)
-most of period given to study for a test on chemical bonding and nomenclature- most students attended to the task quite well, producing a general hum of productive activity- some students socialized freely, "I got a drink of H_2O", I don't know the formula for a chocolate bar so I won't try it".

(Chem 30, Feb. 22)
-listened to explanations and examples, worked on assignments
-seemed generally attentive, concerned about being able to do Hess's Law problems
-one student asked why $C_6H_{12}0_6$ wasn't written as CH_20.

(Chem 30, May 5)
-students helped each other with using logs and antilogs in pH calculations.

3. Use of ALCHEM:

-seems to be the focus of all activity in the classroom
-students are given reading and problem assignments principally from ALCHEM.

4. Comments on Science:

-regarding the molecular formulas of sulfur and phosphorus, "that's the way God made them".
-conservation of energy principle inherent in Hess's Law was not pointed out.

5. Comments on Students:
-excellent rapport with students, friendly bantering atmosphere prevails
-Jensen won arm wrestling competition with a student at the beginning of one class.
-seems to treat students as adults.
-Jensen's comment to his student teacher: 'you have to like kids in order to teach them'.

6. Comments on Teaching:
-emphasis placed on explaining until the students understand
-use drill on "type problems", focus on method of calculation, to get the "right answer".
-reduce a question to a familiar type, e.g., "this is just a Chem 20 solution problem".
-drew out structural formula for glucose to explain to a student who wondered why its molecular formula wasn't CH_2O.
-worked out solutions to all homework questions are posted on Tb at back of room.

7. Comments on Society:
-reference to H_2S in wild sour gas well at Lodgepole last year.

8. General Comments:
-none of the students questioned the relevance of drill exercises on formula writing.

B. First Interview with Mr. Jensen, February 22, 1983

(The interview was conducted in the staff room at Rutherford C.H.S., during Jensen's preparation period.)

1. **Lantz**: I want ask you about how you adapt and modify ALCHEM, and to try and get at why you adapt and modify it that way. Teacher's personal practical knowledge is the thing that I am trying to get a handle on. Sort of the common sense that people develop over the years on knowing what is going to work in the classroom for them, and seeing how that guides their modifying and adapting of curriculum materials for use in the classroom. The first one is just a general question, What do you think of the ALCHEM materials?

2. **Jensen**: Oh I like them, I have used them now for, oh man 10 years, ever since they came out.

3. **Lantz**: Yeah, you were using them at (name omitted), weren't you?

4. **Jensen**: Yeah, I've used them right from the start. I think they... I like them much better than the textbook. In terms of the number of exercises there are to do, and I think it is convenient for the kids to work through the exercises as they take it rather then going through the whole unit and then doing a bunch of exercises at the end of the chapter or something like that.

5. **Lantz**: Okay, two things there I guess... that the exercises are incorporated into the materials, and that there are lots of them.

6. **Jensen**: Right. So generally, I mean, I like it. I have liked it right from the start. And I think the whole thing came about through the... generally teachers making up so much of their own supplementary materials from the CHEM Study wasn't it? And then they just got together and put all the materials together and Frank (Jenkins), I guess, and a bunch of others just took the bull by the horns and turned all these teacher produced materials into a course really.

7. **Lantz**: Yes, that is essentially what happened. It started out basically as a collection of worksheets and then it happened that the Alberta Education was revising the Chemisry Program about the same time and so we were able then to write the materials to fit the objectives that they had laid out and that is principally how it got approved for use in the province.

8. **Jensen**: But in any case, I like it. I think it is a good course for (Chemistry) 10, 20 and 30. I hate to go back to a textbook right now.

9. **Lantz**: Right. Now back to this thing of where it evolved. The worksheet business and that... sort of controlled the format of it from the beginning. Some of the teachers have told me what they think is lacking is in the explanations, descriptive materials, that there isn't enough between the worksheets. How do you feel about that part?

10. **Jensen**: Well, as we saw in the class this morning ...some of them saying that the information doesn't explain enough. They commented on that in class this morning. I don't hear that too much from students... occasionally. You just can't explain everything, I think it becomes too wordy, and I think if you try that the kids get turned off on it. It gets too wordy there is just too much space in there of just words. I think, really, a brief explanation is sufficient and then leave the rest up to the teacher. This might be harder for teachers maybe in various areas that are not that familiar with chemistry, you know like maybe some other country places where more explanations in the book are necessary. But I think in general, as I said to the kid this morning, he made me feel useful. As a teacher you can fill in. I really think it's good if the kids read the notes and it leaves them with questions. If they come to class and they say "Hey, there is something in here that I didn't understand. It doesn't explain it quite right". I think that is a great learning process, of not trying to

explain everything in the notes. Leave something up to the teacher to fill in. I think that is a good way of doing it and I would hate to see it more verbal. If I remember, the CHEM Study material was very verbal. And just to such an extent that an average kid just said, just got turned off for all the words. Where I think we purposely tried to make ALCHEM explanations as brief as possible. Just a bare outline of explanations. And then depending on the class... You see some kids need no explanations some need a lot more. Leave it up to the kids to read it and ask you, and question you in class. Question it and say, "Hey, this I don't understand". This is the way that I like it to operate and so, no, I wouldn't like to see it more fully explained.

11. **Lantz**: Now are there any parts of the ALCHEM 10, 20 or 30 that you omit any labs, demos, exercises?

12. **Jensen**: Some of the ones, especially in the Chem 10. I tend to omit a little bit because it seems to be that there is such a scramble in the Chem 10 to get through the whole course. So often I am in Unit E... D and E, especially E that is so important, that I just don't get through it in enough detail. So I tend to leave out some of the earlier labs and perhaps in B and maybe C. You know, if I see that I am being pressed for time, I leave out some of those labs. I don't like to, and I have to weigh one against the other. You know, is it better to use up the lab time and make sure that you get through Unit E properly?

13. **Lantz**: So you do feel pressed for time in Chem 10?

14. **Jensen**: I do feel quite pressed for time in Chem 10, especially the 10, the 20 to some extent but mostly in the 10. The 20 to some extent, you see so many kids are taking Chemistry. You know all the kids taking Chem 10. There are so many kids in the Chem 10 that are just not, you know, chemistry, you know students, hey?, and you are being held up so often by these students that just can't seem to make progress.

15. **Lantz**: So Chem 10 here is used as the basic science course, even for people who only take three credits?

16. **Jensen**: Well, no, we have Science 11 too. I think that so many of the kids go into Chem 10, for various reasons, you know it's, "Let's get into the academic if we can." Also, perhaps to some extent the school has a reputation as an academic school and if you go to Rutherford you should be taking Chem 10 not Science 11. The emphasis is on that sort of thing. I have really had some students in Chem 10 that are not even close. There is just no way they can handle the material, but yet they are there. You do tend to be held up quite a bit by these types of students because you are trying to wait for them and you are trying to help them and in the meanwhile the other students are chomping at the bit to get going. I think I tend to be held up too much, I keep saying to myself, time and time again, "okay this time in Chem 10 I have to push through those Units A, B and C, much quicker". But it always seems that by the time I hit E I am just about out of time.

17. **Lantz**: Yes, that I think must be a universal problem and that course is just so choched full.

18. **Jensen**: It really is and that is why I think in the 10 there is a lot of detail in there and you just have to skip through some of it.

19. **Lantz**: Now in Chem 10, there is no attempt in this school to screen the students? So you get a Chem 10 class and it is a mixed bag?

20. **Jensen**: Oh yes, oh yes certainly a mixed bag. You get the total range here. You get those at the very bottom end. In other schools they might be taking more vocational or business ed. subjects. Then you get the top of the line students which is great and they can take 10, 20 and 30 in one semester. That's why the IB program was started here for those types of students. But you still get some of those in your

normal Chem 10 classes, you know but...

21. **Lantz**: How is that IB going? There's one or two sections of chemistry?

22. **Jensen**: Yeah, there's the 15 and 25. (names omitted) are doing the chemistry in the IB program. I don't know that much about it really. I am not involved in it really. I got that one student who came to see me at the beginning of the class. Remember, she was talking to me. She want to get out because she had some work with (name omitted), who is our Department Head, in Biology to do. She has transferred from the IB program into the regular program and so she has done most of this energy unit in the Grade 11 IB program and so she told me that. Although she was rather upset because she only made 69, which is just class average. So she didn't like that.

23. **Lantz**: Now in terms of the 20 and 30, anything that you think of that you will...?

24. **Jensen**: Some of the 20's... Oh, by the way, in the 10 I do omit using models. That is one thing, just to.... and I just have them draw diagrams. I don't use the models, I have found that like tinker toys, you know, and they spill on the ground all over the floor and they play with them and they really don't get much out of it. I don't think in terms of models. I use them also a little bit in the 20. Although I omit most of the model work in the 20 too. In the Chem 30 of course I usually omit the organic review unless we come back and do an optional unit on like, "Foods and Analogs", or something. I will come back and do the organic review at that point. Oh, ever since I have been to Rutherford I have never done, "Foods and Analogs". With the semester here it seems like I have time only for one optional unit, and that is usually the nuclear chemistry. I think kids find it most interesting. There is so much controversy going on that point. With the semestered courses you only have time for one option. With the all year courses they usually do two, sometimes even three. I think (name omitted) has as many as three optional units in the all year courses though. But in the semester there just seems to be... you know, you get through one and that's it.

25. **Lantz**: You have taught full year as well? Of the full year Chem 30?

26. **Jensen**: I did one full year here. The first year here I had one class of a full year. Since then I have been pretty well on the semestered (Chemistry 30). I am pretty well the Chem 30 semester teacher here.

27. **Lantz**: You have found as well that you have time for more electives?

28. **Jensen**: I had more then. I did have more time in the full year course to do another elective. I was running a little bit slower than I should have been. I could have pushed them through faster and easily have done two. So if I tell you that... I guess there's some of the labs and model exercises in Chem 10, and some of the optional in Chem 20 (that I omit). I do most of the optional stuff. I know the kids sometimes complain about it. "But how come it says, 'optional'?". I tell them all, "You know, 'optional', just means it's for the very best classes to do, and so we are doing them. Okay?".

29. **Lantz**: So that is one thing where you supplement; you do most of the things that are marked optional?

30. **Jensen**: I do most of the optional.

31. **Lantz**: That would include the stereochemistry in Chem 20?

32. **Jensen**: Yup, I do that. Again, mainly without the use of models. It is hard, you know, just drawing pictures, and looking at diagrams.

33. **Lantz**: Any other things that you supplement?

34. **Jensen**: Well, especially for the 30, I used to give them quite a few extra worksheets to do, especially in the energy. But actually I give them quite a few extra worksheets in all units. When I came here, (name omitted), the assistant department

head, had a whole bunch... piles and piles, of extra sheets made up you know, and all duplicated and run off, nice copies. There was a whole cupboard full of them, and I just helped myself to quite a few of those because the kids need a lot. And I do, especially at the 30 level, give them quite a few extra separate worksheets. When they work in the book, they can work in their book, and we take them up in class and then we check my book for the answers and all that sort of stuff. I think it is good, especially before exams, I give them these assignments to work on and come up with their own answers. Sometimes just to make them work a little harder, I say, "Okay, I am going to collect the ones I want and count them as assignments, count as marks". That gives them a little bit of adrenalin to work on them a little harder.

35. **Lantz**: There was a student's book I was looking in that you had gone through and I think you marked some of her work that was (in her notes).

36. **Jensen**: Yup, I say I am going to do homework assignments. Actually for the 30 class I give them a vote at the beginning of the year, I don't do this for the 10 and 20, but for the 30 I give them a vote as to whether they want me to count assignments or not as part of their mark. Or do they want me to just concentrate on tests. I do it on an in-class vote and give them a secret ballot to fill out - do you want assignments to count as part of your mark? do you want exams only to count as part of your mark? And so far I have had about 80% yes we want assignments to count. Then I give them a choice - what kind of assignments? In-class assignments? Homework assignments? Combination of both? This particular class voted for homework assignments only. I said, "Okay, the homework assignments - periodically I will call in your book just to see that you have everything done". I give them one of these extra worksheets to work on and while they are working on it I will collect their books and just leaf through it to see that they have everything done. I don't check that everything is done correctly I it would just take too long. But they have everything done - 100%. I just start deducting marks for everything that isn't done in their book. Plus I give them some of these extra worksheets as homework assignments to do I say okay take these home and do it. Then I may or may not collect it. I can't promise to collect it all but I will periodically collect one of these homework assignments from them and mark it. In terms of assignments, I usually say if I collect ten in a semester I will average the best eight and count that as one exam mark. I explain that all to them before they take their vote. I count the best eight out of ten assignments and that count is the equivalent of one exam mark.

37. **Lantz**: Which is about 15%.

38. **Jensen**: So I do quite a bit of supplementing. Also films, we do get in quite a bit of films, especially nuclear energy, manage to run through that whole unit just showing films. Quite a few films. This is one thing there are really no ALCHEM films, per se. We are using still some of the old CHEM Study films. Which are okay in some cases, and then just general films from the University of Alberta that we get on these certain subjects. But there are lots of films, but no specific ALCHEM films.

39. **Lantz**: No, that's right. Now with the films, the nuclear energy ones, there would be a lot of those. What about the core units?

40. **Jensen**: Mainly the films that we use in the core units are the old CHEM Study films, like "Electrochemical Cells", there is two or three energy films. I haven't shown any in this unit but there are two or three, I can't think of their names right now. There is "Acid and Bases" and "Acid Base Indicators", that's CHEM Study. But generally speaking, as far as the core is concerned I am still using the CHEM Study films.

41. **Lantz**: Yes, I use those too. One of the frustrations that I had, with the units and conventions were sometimes a little different. Then you had that problem to explain away - why is their table upside down compared to ours. The approach to explaining how an electrochemical cell works was a little different. There were certainly parts of it that were really good and other parts not so good.

42. **Jensen**: Sometimes that is confusing but they, you know I believe, and I tell the kids, "You know, what's wrong with looking at something from a slightly different point of view". Nothing wrong, but a lot of kids really complain. They say, "That just confuses us". I say, "Well looking at something from a different point of a view confuses you then that means that you just don't understand the concept well enough. I think if you understand then you should be able to look at something from more then one point of view, okay?". I think that it doesn't hurt at all to have something like that E° table. To have things instead of an oxidation table to have a reduction table or vice versa, you know because they can say, "Hey this works both ways, doesn't it". I think it can be made beneficial. That type of situation. It doesn't upset me too much that those are backwards. But, you know, I guess it would be better to have some films, I don't know maybe this is something that is coming out in the future. Maybe something can get going and make some films based on exactly what the ALCHEM is teaching. Providing this ALCHEM is going to stick around for the next say 5 or 10 years. Films are expensive business things to make. It's very expensive.

43. **Lantz**: Yes, I certainly think there is potential there for a whole audio visual area, supplementary material to ALCHEM. And the demos, You did one there today, is that a regular one with the sugar, do you have some others of those that you work in?

44. **Jensen**: I do sugar, well I always, "start the year with a bang", with my "singing hydrogen". You know, then the burning sugar. I usually do, like when I go through the labs, I always show them precipitation reactions. I always do the single replacement, like with the reactive metals with water, the alkalis and calcium with water, they are interesting reactions, hey? Kids have a lot of difficulty writing those equations where water is being forced to act as an acid. Active metal plus water. I always do two or three of those, I always show several precipitation type of reactions, because again they seem to have trouble. "Well, what is a precipitate?" You know, at the 10, 20 and 30 level. Some of the kids in the 10 level look at them in the lab. They do a precipitation reaction. You know the usual lead precipitate, lead iodide or something? But I find that it is worthwhile to demo those even in the 30 and explain to them, "Okay, what is a precipitate?, You saw some of those beakers on my desk, they are getting mucked around now, but you know I had all those beakers and stuff with precipitates in them because you make a precipitate when you react calcium with water. It all turns to cloudiness and they can't see when it precipitates. I'll say well, we'll leave it till next day and then we will see what it looks like. The next day you can see that all the calcium hydroxide is settled out nicely to the bottom. Then I say, "Well that is what a precipitate is, you see". Something that is solid is formed and settles out, and I usually do those, and let's see what else... I usually demo single replacement reactions of, you know... showing the formation of bromine by using chlorine, sodium bromide, or chlorine, water with sodium iodide, those types. Things that, you know, redox. Um, I try to do a fair number of demos, you know to keep the kids interested and stuff. I do other things... like I did the other day with the Chem 10's. I have a T-shirt, "The Ionic Man", T-shirt. And then whenever we come to the ions with the Chem 10's... you know the day I am going to talk about ions with the Chem 10's I always ask them how many have seen Superman. And they of course have all seen Superman. Well here is this guy that turns into Superman, and of course they all know Christopher Reeves, and I ask them, "do I look like Christopher Reeves?". Well I say, "I can't turn into Superman, no way, I can't do that but I can"... and I rip my shirt off. And then I have my Ionic Man T-shirt on and then I say, "Guess what we're going to talk about today". I did that with the one 30 class, they thought that was great.

45. **Lantz**: I don't think I have seen a T-shirt like that.

46. **Jensen**: Well, you know its got ionic man written on it. I have several T-shirts. I do with the 20, you know it says, "chemists have solutions". Whenever we take solutions up, the day I am going to talk about solutions I always come in wearing that T-shirt, "chemists have solutions". Then I play some records, I've got a record, maybe you have heard of it it is an old record of Tom Leher now that was back in the 50's but he sings of the chemical elements. He sings a song he does the chemical

elements, he just rattles them off all 100 in about a minute. So fast. I tell the kids you got it, this guy has a song and in the song he has got the chemical elements and I want you to take out your periodic table and check the elements off as he says them and see if he misses any, okay. I have them all sitting there with the periodic table this is in Chem 10 when they first start using the periodic table. I will say as he lists the elements you check them off now everybody get their head down and I'll play the record and of course he says them so fast a few of the kids start checking a few and then they just throw up their hands and say .... You have never heard that Tom Leher It's quite interesting you know. It's good. I usually play it just for the fun of it for the Chem 30's as well.

47. **Lantz**: Any parts of the ALCHEM that you adapt or modify, some of these, we have talked about the modifications but anything else that you use but you sort of change it around a bit when you use it?

48. **Jensen**: Gosh, I can't say anything off hand that I do. I think almost unconsciously I make modifications you know almost everyday. The stuff that is in there or try to explain in a slightly different point of view. I try to work in as much as possible current things that are happening especially when you take energy or when we did acids and bases. I was doing acids and bases last semester we were having that big problem with that blowout with the hydrogen sulfide gas. I try to fit the acid base to, you know, to talk about the acid rain situation that we seem to be bothered with so much these days. That s not realy a modificaion I guess that is trying to relate to everyday happenings, I try to do that as much as possible. In any sort of newspaper articles that is on the stuff we are taking I bring in. Just recently I brought this article in for the Chem 10's on the scanning electron microscope that they are supposed to be producing. In three years I think that is the goal to see an atom. You know try to make it interesting for them if possible.

49. **Lantz**: I see you have a poster at the back on, "The Nature of Things", that program with Suzuki. Are your students encouraged to watch that as well?

50. **Jensen**: I try to, I try to although I put it on at the beginning of the year and I bring it to their attention and then I seem to forget about it for the rest of the year. To tell you the truth, I hardly ever see it myself. It seems like I'm never available at that time to watch TV, or on the board I put that, "Quirks and Quarks", on too, that is on at 12 noon on Saturdays. It just seems like I'm never by a radio, sometimes I'm by a radio at 12 noon on Saturdays. It is an interesting program.

51. **Lantz**: Yes, I really enjoy that. A couple of years ago they had the guy who runs the program, Jay Ingram, was at the Red Deer Science Council Conference. He was a good person to have there.

(Another teacher sits down at an adjacent table)

52. **Jensen**: This is (name omitted). He is the Physics Teacher. Oliver was asking... Oliver sat in my class this morning, and he sort of noticed Mark in there. He was asking about Mark, I never say anything about Mark he asked me first.

53. **Physics Teacher**: He has been very reasonable lately, he has settled down the last couple of days. He has his ups and downs. I really enjoyed Ingram's presentation.

54. **Jensen**: Yeah, Ingram, he's on Quirks and Quarks.

55. **Lantz**: He does the interviewing and sets up the programs.

56. **Jensen**: I like the way they end it, they always end it with some stupid little thing, don't they? You know, I always look forward to the ending. You know, some stupid little thing that they try to suck you in something or other. I wish I had listened to it a little bit more. I just forget about it usually on Saturdays I'm busy doing something else and then 12 comes and goes. The only time I ever get to hear it I happen to be driving in the car somewhere, I listen to CBC and it comes on great.

57. **Lantz**: Now you mentioned that the elective unit that you do is nuclear, and that is about the only one that you have time for.

58. **Jensen**: Yeah, the only ones I have done are nuclear energy. I have done in nonsemestered (Chemistry 30), the *Foods and Analogs* unit. I have done with the 20's the *analytical chemistry*. Now that would be good unit to do in 30. I would like to get back and do that again sometime. But you see, it really is a lot of work to get all these chemicals set up, but if you do get it set up you can use it for all your classes. I think in this school especially, the anion one would be really good for the IB program to look at. I did it back in (name omitted) with my Chem 20's. It was really good then, it is good for the highly motivated top students, that is really a good one. I am not so sure what they are going to do here but I would certainly recommend that as an optional unit with their IB's. Once you get it all set up it is not so bad to run, it is just that there is so many different chemicals. Like I said a lot of lab preparation you know. We have two full-time lab techs here. Which is really great. I just hope we can... you know we cut back in the budget... that we can manage to hang onto two of them. Although they spend most of their time in biology. 60% of the time is biology - quite a large biology lab. Twenty percent in chemistry and one percent in physics and all the rest. Physics gets not too much. With the two of them they should be able to set up these labs.

C. Second Interview with Mr. Jensen, April 13, 1983

(The interview was conducted in the science teachers' workroom at Rutherford C.H.S., during Jensen's preparation period.)

1. **Lantz**: I was interested in your comment that you made a few minutes ago to the student teacher - that you have to like kids in order to teach chemistry or to teach generally. I thought that that kind of fit in with some of the things that you told me about last time. Where you have some neat little demonstrations that you do because... I think they probably relate to entertaining the kids or reflect that you like to work with kids and I wondered what you saw in some of these methods that you use. You mentioned a Tom Leher song about the elements. What does that do for the teaching when you use it. What kind of an effect does it have?

2. **Jensen**: Well I just think that a lot of students find chemistry a big bore, of course, and I just to try to interest them a little bit.

3. **Lantz**: So it is a motivating thing?

4. **Jensen**: Oh sure, sure, motivating, interesting and entertaining, if you want to know. It does all these things. I think that teachers should try, you know, where it fits in, to entertain the students a little bit. You know, gosh, its hard... I think sometimes as teachers, we just forget sometimes how hard it is to sit in a desk all day, you know, for five hours and a lot of the students have to do that. I think we should try to make it as interesting for them as we can without going too far.

5. **Lantz**: No, I agree with you absolutely, and I can remember when I used to get student teachers, That was the time I was always reminded how long the period was, when I had to sit at the back.

6. **Jensen**: Oh yeah, right.

7. **Lantz**: I was reminded again as I came out as a Faculty Consultant.

8. **Jensen**: I feel the same way when I'm sitting in the back watching the student teacher. And I figure "boy!", you know, and then yet I usually don't sit through a whole class. I have... I get up and leave. Well you see the kids aren't allowed to do that. Usually they are not allowed to get up and leave, and some of them play games. Like they ask you, you know, they get up to go to the washroom. Well lots of times they go to the washroom, but lots of times (it's) just because they have to get out of there. They just want to move. Kids, and it is easier for us to still sit, than it is for kids. I mean it is harder for kids to sit still than it is for adult to sit still. I'm quite sure.

9. **Lantz**: I know when I get into a school as a Faculty Consultant, and then check the schedule that they've given to me - I say, "Oh no, this is an 80 minute period. I'm stuck here for 80 minutes before I can talk to the student teacher". That sure seems long. I think there is only one school now that is on 80 minutes and I guess that's (name omitted).

10. **Jensen**: Isn't (name omitted) on 80 minutes now? Still?

11. **Lantz**: Yeah, I guess it is, (name omitted) and (name omitted).

12. **Jensen**: I didn't think they'd changed over.

13. **Lantz**: I don't have a student teacher at (name omitted) though, so...

14. **Jensen**: But I like doing things like that as much as I can. One of the girls, when I was playing that Tom Leher song... the one you mentioned?, one of the girls said, "Well, what is the point of this?". "What is the point of this?". And I said, "Well you just listen and Tom Leher will answer it for you", and right early in the song he says,

"pointless". He says, "This is absolutly pointless". So then I turned the thing off, and I said, "Okay, you have your answer". You see, and this is one of the girls that is terribly, terribly bored in chemistry, and she is failing. She sits in the back and she is unbelievably bored, and I had a talk with her once and I said I'd like her to move up to the front. I said, "Maybe you won't find it quite so boring". And then I joked with her a little bit. "Because", I said, "if I see you falling asleep, I can throw a piece of chalk at you and keep you awake". And keep (you) interested in case, you know, you have to watch me, because you maybe have to dodge a piece of chalk or something She... "Oh no", she didn't want to move. "Things are going to get better". She really didn't want to move up to the front and I wasn't going to move her. I wasn't going to force her to move because of behaviour problems. Some kids that have behaviour problems and are causing a disturbance in the back; I will force them to move. But if they are not causing a disturbance I'll suggest to them that they move and that hopefully it will help their mark. But if they don't want to move then I don't force them to. Some of the kids think it is a good idea if they are failing. I suggest that they should move up to the front and they say, "Hey", you know, "good idea". And I say, "Well next period you come just sit down in the front". I don't *make* them move.

15. **Lantz**: Now the, "Ionic Man", T-shirt and "Chemists Have Solutions", they would be in the same kind of category as something to motivate and entertain?

16. **Jensen**: Sure, just entertain them. When they do ions I wear that T-shirt, and when they do solutions I usually wear that T-shirt.

17. **Lantz**: Students remember that too, I imagine.

18. **Jensen**: What I get most of the remarks from is my singing hydrogen.

19. **Lantz**: Oh yeah,

20. **Jensen**: I do that all the time, and they remember that because it really scares them, you know, because... And as a matter of fact even the principal of the school made a comment, because I had his son in my class here last year. And I did it on the first day, and I got feedback from the principal about that.

21. **Lantz**: Do you go into the chemistry there to explain why it does that?

22. **Jensen**: Yeah, well... Okay, sometimes I do and sometimes I forget. I usually challenge the kids to do that. I say, "Well look what happened". I tried to say, "Why was it quiet from the start?". You see, then, "Why was it - why did it start to whistle, and then why did it suddenly explode?". And then I usually say, "Just in case I happen to ask it on the next exam". And then I get some of them worried about saying, "Hey we better find out about this". You know, and then I usually forget about it. But then usually, because I have said, "Just in case I put in on the next exam", some of the kids usually bring it up in class at a later date. And sometimes I'll explain it then, or sometimes I'll say, "Well, you know, let's think about it a little bit more". I never - unless they really, really push me - I never explain it. I just keep throwing it out as a thought type question that they should be thinking (about). And quite often the kids come to me after class with good solutions and good ideas and then I discuss it with them. But I never have put it on an exam yet because if I did put it on the exam the I'd make sure I'd take it up with the kids. But usually I just leave it as an open-ended question with them or as something to challenge those that want to think about it.

23. **Lantz**: That's great - I remember when you did that at the Edmonton (Regional) Chem Council over in the Faculty Club. They set it up as a report back from one of the Chem Ed Conferences you were at.

24. **Jensen**: Oh yeah, right. That's where I got it. I got it there. I have been doing it in my classes ever since. I usually do it on the opening day. And then of course I end up with a statement that, "I like to start my classes with bang".

25. **Lantz**: Now you mentioned doing alkali metals in water and a redox demo. Are they a similar sort of thing, or are those more standard in relating to the subject matter?

26. **Jensen**: Yeah, I think those are pretty standard. Yeah.

27. **Lantz**: Well when would you do the alkali metal and water one? Is that....

28. **Jensen**: I did... It appears more than once. It appears when we are studying the elements with the Chem 10's and we take the alkali metals, and just again... I wouldn't have to... As a matter of fact, it is getting more difficult to do that because they are starting to remove the so-called dangerous chemicals out of our labs. And we won't even be able to have potassium, sodium, and magnesium sitting around anymore. Yet I find it very interesting. Then I always relate this to the alkali metals and I always challenge the kids. I could say, "You see how important it is that the Fire Department knows, especially in a place like Edmonton's Chemical Row, that they know what chemicals are there. Because, you see, they have to know... because they have to know what kind of fire extinguisher to use". The Fire Department becomes very upset if they don't know what chemicals - because you could imagine what happens if there is a storehouse with a lot of an alkali metal. And there is a fire and the firemen they come and they start pouring water on it... That's a bad situation isn't it? Because the more water they put on it the more it's going to go, and so I relate that fact to the fact that it is very important that the Fire Department know what... So that is a little bit outside and just a little extra information. I always try to bring that in.

29. **Lantz**: Do you bring in this business of disposing of hazardous wastes. They have this collection system among all the schools. Do you tell the students much (about that)?

30. **Jensen**: This always comes up at some time or another. It seems like usually in the Chem 30 classes this comes up, and the kids are quite concerned. Because in some of the electrochemical cells that we do, we use lead cells to copper sulphate and silver nitrate - very weak solutions. They're a little bit leary, you see. We discarded that down the sink, and the kids ask about that, and I say, "Well look, it is a very, very small amount". I say, "The amount that we are putting in the sink is infintisimal relative to the normal amounts that are dissolved by water running through the country side", you know. Yet I'm not too sure whether I believe that. I feel a little bit bad about dumping our unused chemicals, the so-called, "non-dangerous" ones, like a little bit of copper sulphate or little bit of zinc nitrate and stuff. You know, I don't think that's going to hurt the system and yet....

31. **Lantz**: So which ones are collected here routinely?

32. **Jensen**: Um, well I don't think in any of the labs that we do we have routinely collected any of them. Let's see which ones... There have been ones, that we have put in other storage containers, that are dangerous. But generally, most of the stuff that we use in this school, are in such low concentration and non-dangerous. Because really in terms of high school level we are not allowed to use, and we don't use, any dangerous materials. Even in electrochemical cells they were taking away the cadmium nitrate. We don't even use that anymore. Instead of cadmium they have substituted lead. Well you know lead itself is dangerous, hey? I mean really, in high concentrations. But I guess the feelings is that the amounts we use are in such low concentration - like they use a .1 molar solution, and you use about 20 or 30 millilitres of it. It is practically nothing, you know, in our total sewer system. And yet it is something that perhaps should be done. I know the kids ask about that dumping, and I just tell them that the amount we're putting in there is small so I'm not worrying about it.

33. **Lantz**: Do they collect any chemical waste from the school.

34. **Jensen**: I don't think so, no.

35. **Lantz**: They were at Grey. Now I'm not sure if they are still doing this or not. We were on the collection route for the University. (The science supervisor for the school system) managed to get us on to that, and we had a system where they brought these Jerry cans and we'd dump hydrocarbons in one and, I guess, the heavy metals in another. And at the end of the semester they'd come through and haul it out to the (name omitted) dump site and leave us with two empty cans and it was a routine sort of thing. I don't know if they would be willing to continue that on a long term basis or if that was just a temporary thing because there was a little bit of political pressure on this hazardous waste business. You say as far as you know they don't do that here?

36. **Jensen**: No. No, you see, we don't do much in the way of organic experiments. Now you see, organic wastes are the more dangerous ones too, and the number of organic experiments we do are very limited. Because so many of the organic experiments are potentially dangerous to do, you know. So we're sort of not doing them in the classroom, or if we do do them we are just doing them as a demo under a fumehood, and then you just have the one small amount to dispose of and its.....

37. **Lantz**: So with the alkali metal and the water in Chem 10... When you're talking about the elements and you want to identify the alkali metals as family, I suppose that you would do that. And then you mentioned later in redox? Was it the next place that you bring that in?

38. **Jensen**: Um, okay. No, where it comes in again...Yeah, okay, it can come in redox, but it comes in the Chem 20. We talk about solution chemistry and we do net ionic equations, you see, and there you come into that. And also with calcium, because the net ionic equation has a precipitate as well. That shows a precipitate of calcium hydroxide. We always do the calcium with water, which is another very reactive metal, you see, and we try to... I always bring it in - the alkalis with water - with the fact that water is acting as an acid. The alkali is forcing the water to act as though it were an acid, you see. And I try to relate it there with the Chem 20, and the Chem 30 over again, when we review net ionic equations. How that water can be, you know, hydro-hydroxide acid, you know, if you want to look at it that way. So that is why I do that again.

39. **Lantz**: You mentioned a redox demo last time as well. Which one was that? I think the question was about things that are supplementary to ALCHEM, so you mentioned a redox demo that was additional to ALCHEM.

40. **Jensen**: Redox, redox, I can't ..... I was doing an energy demo - I burnt that sugar.

41. **Lantz**: Yup, the sugar and perchlorate one. That'sokay. Maybe I made a mistake in my notes here.

42. **Jensen**: I can't remember. I don't think I do a redox demo. Ah.... You see we do that one, of course, that's in the book. The demo with the electrolysis. But I don't think I have an extra one that I do. I know I was talking about the sugar - the energy one about burning the sugar. Well, you were here for that one.

43. **Lantz**: Yeah, I was there for that one and that one has many of the same functions I imagine as these other ones you talked about. They are interesting and motivating and there is a chemistry background.

44. **Jensen**: And there is a big flame and the kids always like to see flame and fire and explosions and things like that. I am doing less of that then I used to, I am, because I had an experiment over at (name omitted) when I was there. I was doing quite a few demos with the class - interesting ones. You know, little explosions and fires and, you know, I was making up gun powder and we had little rockets. (We were) making up our own rocket propellents in the class, and with a good Chem 30 class. It was either a good Chem 30 or 20 class. I had quite a few students that were really good and they were really interested and we got going. We were making rocket propellents and we had - I remember we had a wire strung from one corner of the

room to the other - and we made our own rocket propellent. And we designed and made our own little rocket out of paper and we put it in there, and we shot the thing just on this wire, swooosh, right from one (corner to another)... and then there was a couple of near fires at (name omitted) Composite High School in some of the mud rooms, hey? And I went down and it very suspiciously smelt like our rocket propellent that we had been using in class. And I got thinking, "Boy, I wonder if these kids....". Most of that stuff they can get. They might steal it out of the lab, they might be able to buy a lot of the stuff in the drug store. And I got thinking, "Well, you know, sometimes its not so good to do this because some of these kids are going to use it for other purposes". And I to some extent cut back on some of my demos, you see, and I know the kids often get after me to do more. You know, they want to see fires and explosions and stuff.

45. **Lantz**: That's mainly a safety factor.

46. **Jensen**: Yeah I'm just concerned about the safety factor and the fact that, you know, that I don't show them how to do it because they... And the same even with that sugar one. You see I just tell them its just sulphuric acid and sugar. As far as they know its sulphuric acid and sugar, you see. I don't tell them about the catalyst I have in there.

47. **Lantz**: Yeah I have a similar sort of experience to. I used to do a lot of demonstrations when I first started teaching. When I think about some of them now, I was lucky that nobody got hurt. I used to manufacture acetylene and set it off and all kinds of potentially hazardous things.

48. **Jensen**: Right, I used to do that chlorine and hydrogen one too. You know, you put it in a glass and I would shove two corks in the end, and then you'd flash flashbulb at it and those two corks would end up anywhere in the room. They'd make about three bounces back and forth across the room. The kids loved it. It was great. They'd just go, "whamo!", you know, just like a shot gun. And shoot those corks and they'd would... man I would usually aim it so one cork was aiming up at the far end of the room and the other cork was aiming down at the front. And I would put a little mark on the corks, so I would know which was which. And the one that hit the front would usually end up some where around the back of the room and the one I was aiming at the back corner would end up somewhere around the front of the room. You see, because it would it hit the back corner and bounce. But they were corks and nobody got hurt, but you know I finally started using an explosion shield. When I first started it, I never used an explosion shield. I wrapped the glass in masking tape so that if it did shatter - it never did shatter because it always blasted those corks right out. I think you know. Its very, very interesting but I was always a little bit leary of it, you know, because it really exploded. With hydrogen and chlorine in a one to one ratio... that will explode on... just light, a strong light. So there is a certain amount of danger and I have tended to - maybe its old age too. I'm a little less, "gung ho", to do things like that. The kids sure like it. They think its great.

49. **Lantz**: Okay, moving on to another thing from last time. Um, you mentioned that you pick up some work sheets in the electrochemistry units. I think from (name omitted)? What are they about, and what is their function?

50. **Jensen**: Well so many of the kids need, they are always asking for extra worksheets, hey?. And especially in the energy unit you get, oh heck, I must give half a dozen or a dozen separate worksheets in the energy unit and we've got virtually hundreds of worksheets, most of the are (name omitted) and some of them are mine. But I always made up worksheets for the kids, extra worksheets. But I usually just did on it on ditto stencil, and then as I came to it I'd make it up. I never had it so completely organized as he's got it. He's got whole piles of them in there and they're all typed up nice and duplicated, hundreds of copies, hey?. So you just grab out copies and distribute them to the kids and it works quite well and it gives them a lot of extra practice, you see, to do it. I find that useful, especially for the energy unit.

51. **Lantz**: Also some in electrochemistry - I guess?

52. **Jensen**: Oh yeah. There's lots in electrochemistry and lots in acids and bases. I find that I generally don't use as many in electrochemistry and acids and bases. In fact I seem to go downhil!, like, I use lots and lots in the energy unit and I use a few in the electrochemistry and then I use only a couple, maybe, in the acids and bases. I find that the kids don't seem to have quite so much trouble as we go. They always have most trouble with the energy unit.

53. **Lantz**: These are generally mathematical problems?

54. **Jensen**: Yeah, sure. They're all problems similar to the ones that are in their book. Just more of the same things. I use them for a number of reasons. I use them as... just to give them an in class assignment to work on, or I just give them the answers and then we take up some of them. I give them to them as assignments. I may or may not collect them. Um, and sometimes I give them more to.,. like I collect in their books to check their work. Sometimes when I want to collect their books in to check, I don't want to keep their books because they may need them right away. I just give them out one of these work sheets. I say, "Okay, hand your book in, and then while I'm marking your book, do the worksheet". Usually we're through about the same time. It takes them about half an hour to do the worksheet. It takes me about half an hour to check their book. Because when I check their book I don't check that everything is done correctly. I just check that its done. I give them credit. Like, if they have it all done they get a 100 percent, whether its done correctly or not. As long as they haven't just written garbage in there. I told them this right at the beginning. As matter of fact I give the kids a vote. I mentioned that to you before, about whether they want assignments to count or not. They vote at the start, and so far they've always voted that they want assignments to count. Some of them come up to me before the end and they say they'd like to recind their vote. But, ha ha ha. I give them a choice as to how they want them. Do you want only class assignments?, do you want homework assignments only?, do you want a combination of both? How do you want this to work? Like this round where both my 30 classes don't want any in-class assignments. I mean, I'll give it to them but they won't count, so any in-class assignment I give them to do in class doesn't count. The only thing that counts are homework assignments, homework checks and stuff like that. Stuff they got to do for homework. Either in their book, stuff I've assigned in their book, or like you heard the question this morning about, " are you going to collect our books". Well some of them at the start said, " Well you tell us the day your going to collect our books", and I said, "Well no you just have your book ready all the time". You see, like I told the kid, "like a boy scout, have your book ready all the time so that when I collect it there is no gnashing of teeth and pulling of hair". Because I always get a few kids that gnash their teeth and pull their hair when I collect their books because they are not ready. I don't think I'm unfair, I don't assign them 15 pages to do and then next day collect their books sort of thing. I don't think I'd ever do that I give them ample time, stuff has been assigned for 2 or 3 days and then I collect their books.

55. **Lantz**: I made a note here at one point, that you treat the students as adults. I noticed that today as well, that you have a serious talk with them about coming late. You were talking to that one kid privately, about not coming late all the time. In a number of other ways you, sort of relate to them as responsible adults. Do you think that is a correct statement?

56. **Jensen**: I think so, I try to . You know as I explained to the kids, anybody is going to be late once and a while, I mean, sure but if I see you coming in late everyday I don't think that is necessary.

57. **Lantz**: They seem to respond to that pretty well.

58. **Jensen**: I don't know if it does any good or not I think - this particular kid I was talking to he's a pretty casual, low achiever, you know.

59. **Lantz**: The elective units, we talked about last time, you mentioned, *Nuclear Chemistry Foods and Analogs*. Do the kids vote on that and select those, or do you pick them out?

60. **Jensen**: Um, the nuclear is, a as I call it, "a compulsory option", because we all do it and we put it on the final exam. Now if we have time I give them a vote, but I find that in the semester classes that I am teaching, there is just no time to do more than one. Now in the non-semestered all year courses you have time to do two and sometimes maybe even three. I think I would be tempted to, it depends on which ones we have available in the school. You see, I would look and see which ones we have available. We order them but if they are available in the school I would rather use the ones that are available. And if we have two other optional units that are right up in our store room, they are available. I think I would say, "Okay we have this one and this one, which would you like", and I would give them a choice. But they really don't know what choice, but then by giving them a choice at least they've made the choice, and if they are unhappy with it, it's their fault and not the teacher's. That's one of the things at this effective teaching seminar that I took last year, one of the things that came out. As much as possible you know let the kids at least think that they are getting a choice, that you are not dictating everything to them. I think a lot of them feel pretty downtrodden almost like a prison in school. And you know I joke with them a little bit, and tell them that I like to run things democratically - as long as they do exactly what I say. But I do try to give them a choice.

61. **Lantz**: One comment that you made last time, is that you would hate to see ALCHEM become more verbal, that is, more textual materials for the students to read through. Since you use extra worksheets, would that mean that if you were going to make some suggestions for ALCHEM revisions, it would be to put more problems in the materials which teachers could choose to use if they wanted to?

62. **Jensen**: I wouldn't put them right in. I possibly... there possibly could be published for teachers that need it, an extra little book of extra questions and sheets you see that could be available for the teacher, but I don't think they need to be in the book as it is. I really feel that there is enough in there. Because you know, you have to give the teacher something to do and you have to explain a few things, and you don't want to make the course look too overwhelming to the kids. I really think there are lots of questions. There is a lot more questions generally to do in that book the way it is designed than say in most textbooks. Especially, you know, the CHEM Study and stuff... a lot more good questions to do. Right now I think you need a revision on the teachers answer sheets, a lot of those answers are out of date now. We need a revision on the test item booklets too, you see.

63. **Lantz**: Are you using that word processing facility where you can phone up and give them the numbers of questions and they will it print it up for you?

64. **Jensen**: Nope, I've never used that.

65. **Lantz**: I haven't either. It was just coming in when I left Grey, but I heard from (name omitted) that he had done it and he was kind of pleased with how it had turned out.

66. **Jensen**: I think it would be very useful for a smaller school where you don't have the typing facilities. I just find it so good here that that I can just go into the book and say I want this question, etc. and take it down and two or three days later the whole thing will be typed up ....(too much background noise).... You're talking about the ALCHEM, one thing I have a sort of complaint about - I don't know how to get around it. But in the ALCHEM 10 - Unit A and B which is generally very simple stuff, and a lot of the kids can do just from the junior high experience. They can write formulas, especially if it's multiple choice questions, and they get a real good marks. And I have found with a lot of kids that they would get pretty good marks in A and B and then their marks go steadily down in C, D and E. By the time they get to E, they've wiped out completely, but they still pass the course because of the strength of their marks in A and B. And yet they didn't understand stoichemetry at all and they go on into Chemistry 20 and they didn't have a clue. Now some of them would pick it up,

but most of the kids that are in that sort of shape really get into Chem 20 and they complete wipe out, and you wonder, "How did this kid ever get into 20 and they haven't even got an idea about stoichiometry?". Simply because they got through Chem 10 with, say, a 48% which we call 50% because they made 60 and 70 in Unit A and B. What I did, I have tried to make the units A and B a little more challenging and tried to stay away from multiple choice questions as much as I can. I think it is kind of ridiculous to say what is the formula for say silver sulphate and then give them four possible choices to choose from. You see, what is the formula for sodium sulphate? they have to be able to write the formula down. They have to know how to write that formula, you see. Also, in my effort to try to bring their marks a little more into line with, you know, what they are going to make later on, I have gone more to... not a lot of emphasis, but at least some emphasis on naming rules. That is, going to the names of complex ions other then ones that are right on their sheet. You know, they have to use their heads and use nomenclature type of rules, hey?. And how to name acids, hey? And in fact what I have done, I think, is brought the mark down of kids so that they don't end up passing the course on their strength of their A and B mark when they are really bombing on stoichiometry. Now what's happened to me is that I have not been really criticized but I've been *asked* about it because I seem to have more kids in the 0 to 39 range in my Chem 10 and in my first report card, which is on your A, B and C. I've got more kids down in that low range than the other teachers. And of course when the administration looks at it they say, "Oh, how come this guy is failing more students then the rest". They just ask me about it, you see, and I sort of explain, "Well, that's the reason".

67. **Lantz**: When it comes to the final though you're probably sort of in line.

68. **Jensen**: I think so, but I have done that. That's one thing I have tended to modify with the ALCHEM. Like I say, I have tried to make A and B, as I put it, more interesting. Those kids really can't do this stuff. I have more kids from 0 - 39 and mainly because I don't do multiple choice exams. I do... you know, like the last exam I gave, which was a midterm - A, B, C. There wasn't one multiple choice question on it. It was all problem, hey?. I expected them to write some fairly difficult formulas. Like it just wasn't all right off the sheet. They had to know the rules and they had to know how to name atoms.

D. Third Interview with Mr. Jensen, May 11, 1983

(The interview was conducted in the staff room at Rutherford H.S., during Jensen's preparation period.)

1. **Lantz**:(refering to the summary of the SOS responses for Jensen's classes) I was surprised at how close they were and how close your (Chemistry) 10's and 30's were to some of the other stuff I've done.

2. **Jensen**:(reading from the summary sheet) "Interesting information and activities". That's where some of the low ones are here. See, "2.0". "Biographical sketches". Most of them don't like the biographical sketches.

3. **Lantz**: No, they don't seem to.

4. **Jensen**: It depends on the teacher, too. You see, I think if I put more emphasis on biographies, more emphasis on the scientists and really talked them up a little bit in class, that probably would have been higher.

5. **Lantz**: Let's look at the (Chemistry) 10 for starters.

6. **Jensen**: The 10?

7. **Lantz**: Yes, as you look at the ones for the 10, is there anything there that surprises you at all...., or what do you make of it?

8. **Jensen**: Oh I see, the fourteen things are ranked in order... At the bottom are "biographies" and "the lab on safety and efficiency in the lab". That's one of the first ones. Really, I suppose... I think kids generally in chemistry are disappointed in that they don't get to fool around more with chemicals. I think they have an idea that when they go into chemistry they think, "Boy, all this lab and chemicals and we get to put all these chemicals together and make all these nice things." They think that. I think they get disappointed and they find that most of their work is class work; it's not lab work. I think this is not a fault with ALCHEM. Any chemistry course, in fact. I think my experience with ALCHEM and with the CHEM Study, there is actually more emphasis on lab work in ALCHEM than there is in the CHEM Study. What chemistry courses are there? I think there is less lab work than we would like to admit to when we write up the course description. We say lab work. Well, there is lab work but not as much as the kids would like to see. I think the teachers are kind of stuck with it. I mean, we have got to get through a certain amount of material. You can't be spending that much time. For example, Unit D. In Unit D in Chem 10, there are basically three labs: D1, D2 and D3. In D1 they go in and they weigh out a mole; in D2 they have to figure out how many moles; and in D3 they have to weigh out a required amount. They have to calculate a required amount and weigh it out. You can see that. Usually, for Unit D, because I'm usually getting rushed at this point, I usually skip D3 and other times I've just done Lab 1. We either do two of them together or, like I went in yesterday and did Lab D2. I showed them a mole from Lab D1 and then did Lab D3. I think in the rush to get through all the material, sometimes maybe we don't go into the lab as much. I know the kids want to. We've only had to use chemicals last day. So I can see that that's low.

9. **Lantz**: There are two things they want. That's the one on, "safety and efficiency", the first one that comes in Unit A. You're suggesting there that they find that pretty dull stuff. They are expecting something a bit more exciting?

10. **Jensen**: Sure, explosions and light.

11. **Lantz**: So they rated that low on all the categories there. In terms of being interesting it is at the bottom.

12. **Jensen**: Yes.

13. **Lantz**: There is another one about lab work and that comes number six in terms of understanding chemistry.

14. **Jensen**: Six... lab work... number six. Yes.

15. **Lantz**: In terms of preparing for exams it's nine and in terms of being interesting it's number two. What you said there seems to be borne out by the fact they actually find it quite interesting. In terms of interesting activity they put it right up there.

16. **Jensen**: Okay, but still even though "interesting" is still higher, even though it is number one. If you look on a scale of five, they still only gave it the same rating as on the other one. Like number nine, 3.8 is exactly the same as for "exam preparation".

17. **Lantz**: It's just the other things are more boring.

18. **Jensen**: Yeah. The, "interesting information or activity", are all generally lower. Interesting how they give the "lab work... explanation of chemical content, information about sources...." Generally, the, "interesting information or activity", is all quite low, isn't it?

19. **Lantz**: That's right: 3.5 for the periodic table is the highest. They find it interesting and I wonder why. Maybe because it organizes information. It's got the ions on the backside.

20. **Jensen**: We're using it at all times. They just came into me today, "Can I get a periodic table?" I suppose I should be charging them ten cents or something. They need and they want to have a periodic table because they just can't do anything without it. It keeps the whole chemistry unit together, the table. They've got to have found that out.

21. **Lantz**: Right, and I think the ALCHEM 10, 20, 30 is particularly built around that. We put information on to the periodic table.

22. **Jensen**: Oh, sure. I do, too. I really emphasize it. I really do in Chem 10, too. I tell them, "Know the periodic table. You won't have to memorize it but know what is on it." I keep emphasizing, "Know what is on it." And when I come to Unit A exam, I throw little questions on it like, "What year was a chemical discovered?", and "What's the boiling point?", without really covering it in class. Most of the kids get it. A lot of kids are caught. They don't know where to look. I point out a few things but I really emphasize, "Know what's on it, know what to find on that periodic table, look over all the information it says. Study it. Always on a Unit A exam, these are some of my questions. Like, "What's the boiling point?", "When was it discovered?", "Who discovered it?". And all of a sudden, "How are we supposed to know that? You expect us to memorize all that stuff?!" When they find out it is on the periodic table they get sort of mad at themselves and kind of mad at me, too, because I tricked them. But I didn't really. I really put a lot of emphasis on the table and knowing how to use it. I think it is quite important. It's much more important to me than just memorizing. I remember when I took Chem 10 in high school, we weren't allowed a periodic table so we had to kind of memorize certain things about it.

23. **Lantz**: You had to memorize even the atomic weight?

24. **Jensen**: Yes, the atomic weight and things like that.

25. **Lantz**: One of the criticisms that one of the chem profs mentioned when we had him out to Earl Grey, was that the ALCHEM students seem so dependent on their ALCHEM periodic table and data sheet.

26. **Jensen**: Oh, yes.

27. **Lantz**: Apparently they even prefered the ALCHEM data sheet to the university data sheets. They wanted to go with the one they had before. I don't see that as serious, now. I think they can adjust.

28. **Jensen**: Oh, I think when the time comes. Naturally anybody likes to hold with what they are used to using. That's perfectly natural. It used to be though, that the first they ever got a data sheet was in university. You see, in CHEM Study we didn't give them a data sheet. We just gave them information from the book. All of sudden, in university they are given a data sheet and "Hey, that's nice!"

29. **Lantz**: It's all summarized and by itself.

30. **Jensen**: Yes, it's like a cheat sheet. You don't like studying chem, you don't need a cheat sheet, we will give you one. I think that they never used to have that until they got to university. Now they get it before that and the university is giving them one. Naturally, they want to stay with the one they are familiar with. I can understand that. But, "interesting information or activity", is quite low.

31. **Lantz**: That's true. They are all lower means. Just looking at other things..... "For gaining an understanding of chemistry". What they see as helping them gain (an understanding of chemistry)... They put the periodic table right at the top. The worksheets, the examples, and the explanations that are in there, they rate all those quite high. Is that surprising to you at all?

32. **Jensen**: Umm... Some of them complain about the explanations of concepts. They say that it is not explained enough. I always tell the kids that that's great. That's what I like because then it gives me something to do and I can feel useful. I can explain. But really they rated it quite high so, you know, that's good.

33. **Lantz**: And the lowest one there is the biographical sketch. You mentioned because you don't stress it very much, they probably don't see it as really a part of chemistry very much.

34. **Jensen**: Yes.

35. **Lantz**: Human interest - that's alongside of the chemistry. In terms of preparing for exams, I think the order is pretty much the same. The periodic table ranks at the top again. The overview exercises come much higher, as you'd expect. The ones at the end of the unit for reviewing, and again, the worksheets and the explanations. Their mark on examples suggest that they must go to those things when they are preparing for exams. It is interesting that objectives don't come all that high. 3.9 is kind of low, sixth on the list. Part of the idea of putting those objectives in was that when students are studying for a test, they can go and look to see what they were supposed to be able to do. These students don't rate it all that high although some of them have.

36. **Jensen**: You know, as a teacher I make up those tests. I should be going to those objectives. I don't. When I make up a test I go through the unit page by page and pick out questions rather than look at the objectives at the front. I just go through the whole unit, page by page, and pick out questions pertaining to that part in the book. I, myself, don't use those objectives. I think the students probably use them more than I do.

37. **Lantz**: I know in that item bank that was made by the school board, they used the objectives as a guideline. They were categorized by objective, which is a bit of a problem because I think those objectives could be rewritten. Some of them don't really get the sense of what the unit is about. They have to be redone and streamlined. Then they'd have recode all those questions.

38. **Jensen**: Yes, yes. This is what I did, I just went into that book for, really, the first time I really went into it because I wanted to give the 10's a review exam. It is going to be like the final - multiple choice. Rather than go through and look at these

objectives, I went through and looked at the questions. You know, I think, "Is that question dealing with what I've covered in class?" That's one thing, I pick out questions that I know they should be dealt with in class and that I know are in their books, rather than looking at the objectives.

39. **Lantz**: With the standard deviation here, the bigger that is, the more spread out the students' opinions are. With the biographical sketch there is a 1.1 which indicates that there is some difference of opinion here. Some of the students must enjoy them more than others.

40. **Jensen**: Yes. Any questions that I ever give on an exam on biographies I always make them multiple choice... almost always. Except in the Chem 10's there is only one or two guys and I expect them to say who was instrumental in helping to develop the periodic table. I expect them to know that. Generally, questions of that nature on my exams are multiple choice.

41. **Lantz**: One thing that I am curious about ~~too,~~ is the information about the sources and uses of chemicals, that work into most of the problems. There is always some kind of comment on their worksheets. In terms of helping them understand chemistry, 3.6. There is quite a wide range of opinion there, 1.1 standard deviation. Same thing for 'exam prep'. It comes in the middle. In terms of being interesting, it ranks a little higher. It is fourth and the students must see that as interesting. Is that the sense you get from the kids? Do they find some of that "What the use of this chemical is..." fairly interesting?

42. **Jensen**: I hadn't really noted that too much. I find it interesting. I like it. I like it there. But, once again, generally speaking when I'm going through that I just leave it up to the kids to read it. I point out a few of them, just a few but I certainly don't sit down with the class and go over that whole thing. I tell the kids at the beginning that a lot of this stuff I expect them to read on their own. I assign the formulas and I check the formulas to make sure they are writing the chemical formulas in and giving them a name. In between is the sources and uses and stuff. I usually don't go over that with them. I don't. So they are doing that on their own. And again, I think that if we were to do a little experiment. If I had a Chem 10 class and I put a lot more emphasis on that and really covered it in class. If we had an exam in it I bet that would be way different.

43. **Lantz**: Yes, that sounds logical. In a sense you are saying that this pretty much reflects the way you use the material, with the biographies it comes down low...

44. **Jensen**: Yes, I think so. The same with the biographies. I don't really spend time on it. I just assign it, tell the kids to read it. I may mention it in passing but I don't stress it. I remember you were doing biographies quite a bit in ALCHEM. First, you had the sketches, biographies over at (name omitted)... Remember, this whole book on biographies?

45. **Lantz**: Yes, that's right. Asimov.

46. **Jensen**: Yes, Asimov. That's good, that's a good one. I would like it. I find that quite interesting, yet I find that I just can't take the time. Especially the Chem 10 course, I really have difficulty getting through to the end of Unit E by the end of the semester.

47. **Lantz**: That's certainly a factor with the Chem 10 course.

48. **Jensen**: You rush and a few things you leave out. Like, you don't spend a lot of time talking about the sources and uses of chemicals. You don't spend a lot of time talking about scientists. You don't. You just assign it for the kids to read for homework or whatever and you go on to explain how to write formulas, how to write equations.

49. **Lantz**: The basic chemical principles?

50. **Jensen**: Right.

51. **Lantz**: Yes. I have, incidentally, never been very satisfied with the way that biographical thing worked out. I was never able to get the kids very keen on it. Occasionally, if you hit a very interesting person they might turn on to it a bit. They always saw it as something beside the point. The keen students wanted to get on with learning chemistry. They knew I wasn't really going to test them on it. That's the life story. The other one is that I have never been very sure how to bring out some of the ideas on how science developed. You should be able to do that through the biographies. How somebody develops a theory, how the theory lasts for a few years, paves the way and then somebody replaces it. You get some sense of the nature of science from the biographies. I've never been able to do that very well. It's something I'm very interested in.

52. **Jensen**: I think this would work a lot better with the I.B. students. A lot of these I.B. students, of course, are really interested in marks. But, a lot of them are interested and so they don't mind. "Hey, this is science. I couldn't care less if there was an exam on it or not; I'd like to know about it." Some of them might be more inclined this way. So many of your students, especially your low ability students, the only thing that matters is if they are passing this course. Anything you give them they say, "Well, are we going to be marked on this? Are we going to be tested on this?" Sometimes I just get so frustrated because *everything* you give them in class, "Are we going to be marked on this? Is it going to be on the test?" or "Are you going to check this assignment?" Well, that's a good question.

53. **Lantz**: They even got that way about the questionnaires. It was a joke, I think, (but) there was a little bit of truth there.

54. **Jensen**: Oh yes!

55. **Lantz**: They want to know if they will get credit for doing it.

56. **Jensen**: Yes, and I get frustrated and I think sometimes..., Quite often I say to the kids,"My God, just do it, eh?!" You know? I realize that's not promoting very well. I'm just expressing my own frustrations. Yes, there is so much emphasis on that. I haven't emphasized biographies and I haven't stated to them that these biographies are going to be tested. They won't bother with it, most of them.

57. **Lantz**: Let's look at the one's from the ALCHEM 30 kids. There were thirty-six students there all together. The same sort of organization with the three categories. The means and standard deviations given alongside. I think, as you noted, the order is pretty much the same. The data sheet comes in... Oh, pardon me, the periodic table doesn't rate quite as high this time. But the data sheet comes in...

58. **Jensen**: In ALCHEM the data sheet is higher than the periodic table for understanding it. It really is the data sheet. Again, that's new to them. They didn't have it for 10 and 20. All of a sudden they've got something new. That is their cheat sheet. They are used to, in Physics, making their own cheat sheets. Now we just give it to them. And that's got everything on it. I think they are quite overwhelmed at first. By the time they get through acids and bases, they realize just how much they use it.

59. **Lantz**: I guess the thing that I seem to see here in the first one as to what they see as helping them understand chemistry are the fairly compact and condensed things that enable them to get a hold on some of the problems. Like, they worked on examples; they rate that at the top. And the data sheet is very close and the periodic table, all of those things are sources of information. In the examples, if they can get the handle on how to do the questions, from their point of view, they are understanding chemistry. Anything there that surprises you?

60. **Jensen**: Demonstrations aren't rated as high. I think the demos are pretty good in that Chem 30 course. Of course, I'm doing it so I am interested in them. The kids are just watching me and they are bored. I like the demos especially at the 30 level.

Especially that redox one and the acid/base demos. I think that is good stuff yet the kids rated it quite low. Again, you see, I'm doing it. I think it is good. They are watching me so they get bored. If they did it themselves they'd probably think, "Hey, this is great."

61. **Lantz**: For "exam preparation", certain kinds of things are rated high again: the examples of the math problems, the overview exercises, the periodic table and the data sheet - compact sources of information. The demos and the biographical sketches come quite low. Biographical sketches I can see because they are normally not on the test. I guess the students, perhaps, don't realize that some of their understanding of the principles come from the demonstrations. They just don't see it that way.

62. **Jensen**: No, the demonstrations are not too interesting for them because they are sitting in their desks.

63. **Lantz**: It is difficult to get them participating in them in that sense, too, especially for some of the longer demos. The ones that come to mind are those acid/base ones where you do a titration of phosphate or something like that.

64. **Jensen**: Oh yes, you get two titrations.

65. **Lantz**: Where you've got these three steps that you are supposed to get. That can take a long time.

66. **Jensen**: Yes, some of them get pretty restless. It's the same with that redox one where you do the redox on those four solutions. I do it over two days: two of them one day and two of them the other. I always save the sodium chloride for the last because they all work out beautifully and then all of a sudden it doesn't work out right. I think that stuff is great.

67. **Lantz**: How do you do that then? Do you say, "We have a system here and we can predict what is going to happen"?

68. **Jensen**: Yeah, and then you get to the sodium chloride and there is something wrong. We emphasize,"Hey, there is something wrong here." I check to make sure no gas leaked out because they've all done it, they know that hydrogen and oxygen should be produced. We get a gas on one side and not on the other. I lead them on saying that maybe the thing is leaking. Something really went wrong and then its, "Ha ha on me." I've messed up on the demo.

69. **Lantz**: How do they take that when you get to the point that the system just doesn't work?

70. **Jensen**: Most of them just accept it. There are a few arguments. I've got a couple of students in that period that are good students. They are really working on the fact that not everything works out the way it's supposed to. They start kidding me. Like when we did the redox one where we have to do the equations differently than the lab before. Then in acids and bases, we start writing acids and bases differently than we did in 20. They ask me, "How many more times are you going to be lying to us?" "Are you sure this is the way it is going to be now?" And I'll say, No, probably when you get to university you might run into different ways of looking at it. Not the wrong way, it is just a more complete way of looking at it. They come to accept this pretty good. The fact that something doesn't work out, like, I say, "One of the nicest things about chemistry is all the rules. One of the nicer things about chemistry is all the exceptions to the rules."

71. **Lantz**: I used to tell the kids, "We told you this in Grade 10 but you are older now and we can tell you more of the truth. You wouldn't have been able to handle this in Grade 10". They're not sure whether that's a compliment or not.

72. **Jensen**: More of the truth, more complete. The thing is, we didn't lie to them. We

weren't giving them false information. We were just giving them not the complete thing. It makes sense and I think most of them, especially the better kids accept this. Some of the poorer kids get frustrated if things aren't just exactly the way they are supposed to be.

73. **Lantz**: In terms of what the students find interesting, lab work is right up there. I guess basically, the information about sources and uses of chemicals is fairly interesting.

74. **Jensen**: These interest things are all lower. Even though the lab work is the most interesting, it is still only in the 3.8 category, much lower than for "exam preparation which is 4.3; gaining understanding is 4.3. The "interesting" always starts a lot lower. The interest aspect is away down.

75. **Lantz**: I guess we can imagine as they did the questionnaire, those three questions came one after the other and they probably put those higher and when they came to interest it dropped down a notch or two. I think I heard some kids talking about that afterwards.

76. **Jensen**: Not interesting though. How can an academic subject be interesting?!

77. **Lantz**: That covers most of things I had. Anything there that you didn't know before?

78. **Jensen**: I don't think so other than the demos and stuff were quite low. I'd be interested in some of the comments that they made. I never looked at any.

79. **Lantz**: I haven't done that yet, either. I have them in an envelope. I noticed that they had written fairly complete answers and that's very helpful. When I get through those maybe I will come back again and summarize the comments.

80. **Jensen**: I told the kids, I said, "I will not look at these at all." A lot of them wonder why they have to put their names on these things. I said that I didn't think it was really necessary to put their names on it. It really wasn't, was it?

81. **Lantz**: On the single page?

82. **Jensen**: Yes, and I said that I really hadn't checked to see if it was there. I said, "I'm not looking at any of this so if you are worried about putting negative comments don't worry about me."

83. **Lantz**: No, this one I didn't need it, just on this one to double check what grade they were in.

84. **Jensen**: There was a place for a name on the multiple choice type, on the answer sheet. They asked me about that and I said, "You may as well but I don't think it is necessary."

85. **Lantz**: I wondered about that. I guess you sometimes inhibit people by asking them to give their name.

APPENDIX I

A. Observation Notes from Glenview High School

The School

-school is in a large two storey brick and concrete building, constructed in the early 1960's.
-school has more than enough space for its current enrollment, giving it a sense of roominess.
-the building is clean and well maintained.
-new student-painted murals decorate some of the hallways.
-students in hallway seem pleasant, respond to my requests for direction, otherwise take little notice of me.
-office staff is very helpful.

The Program

-the Assistant Principal (AP) responsible for the science program gave me a copy of Glenview's "Course Selection Booklet", which includes the following information:
    -the school's policies and programs.
    -requirements for high school diploma.
    -course descriptions.
-AP pointed out the broad range of programs offered in the school, including:
    -academic.
    -creative arts.
    -business education.
    -vocational education.
    -academic enrichment program.
    -high school preparation program.
    -work experience program.
-AP indicated that the science department has six full time teachers, including 2.0 F.T.E.'s in chemistry.
-AP noted that the current administration is, "trying to consolidate the science department again", as it had been, "farmed out to Phys Ed, Voc Ed, and Math teachers"
-currently only one non-science teacher in science department, a female Phys Ed teacher who teaches two biology classes.
-AP gave following figures for science enrollments:
    -Biol 10/20/30=330/180/180.
    -Chem 10/20/30=330/210/150.
    -Phys 10/20/30=150/90/90.
    -Science 11=380.
-there is one "E" section (academically enriched) for each science course, except Science 11, and the school is looking into having students write the advance placement test at university.
-AP gave me a copy of the "Budget Committee Report" which outlines the school priorities for next year.
-met with Science Department Head (DH) who confirmed the science course enrollments given by the AP.
-DH gave me a copy of the timetable and the budget document for the science department.

Classroom Setting

1. Main Features:
-on second floor of the school.
-approx. 6 m X 6 m.

2. Windows(W):
-along the right wall, equipped with venetian blinds.

3. Blackboards(Bb):
-green boards along front and left walls.

4. Tackboards(Tb):
-small tackboard in the rear left corner.

5. AV Equipment(AV):
-permanent screen mounted above front Bb.

6. Special Equipment(Sp):
-induction coil, cathode ray tube, electroscope on demo desk.

7. Shelves and Cupboards(S/C):
-along back of room, lower deeper shelves have sliding wooden doors, upper shallower shelves have sliding glass doors (all seem to be empty).

8. Wall Charts:
-ALCHEM periodic table mounted above side Bb.

9. Posters:
-winter scene in the mountains.
-map of forest zones in Canada.
-map of Alberta.
-national parks poster.
-cat in chair ("daydreaming is my best subject").
-Edmonton Planetarium poster.
-National Wildlife Week.
-comparison of trees.
-Alberta Wheat Pool Calendar.
(Most of the posters are old and were likely put up long before Kurelek started teaching here.)

10.Desks:
-student desks are movable, sloping top, no sidearm, five rows with seven per row.

11.Clippings:
-magazine clipping on insects (old & yellow).
-newspaper clipping on buffalo.

12.Other:
-Kurelek only teaches Chem 10 in this room, Science 11 and Biology 20 are taught in another room next to the biology lab.

13.Teachers' Office:
-Kurelek has a desk in the Science Department workroom, along with all the other full time science teachers.
-the workroom is a converted classroom which has ample space for teachers desks, a worktable, reference materials, tests and worksheets, an electric kettle for making tea and coffee.

Teaching Strategies

Classes Observed
-two Chem 10 classes on atomic structure (Feb. 21)
-Chem 10 class on chemical bonding (Apr. 6)
-Chem 10 class doing lab on molar masses (May 19)

1. Teacher Activity:
(Chem 10, Feb. 21)
-explain energy levels of main group elements.
-ask questions of student re build up of electron energy levels.
(Chem 10, Apr. 6)
-had students put HW on Bb, corrected it with yellow chalk.
(Chem 10, May 19)
-supervised students using balances, providing help to students who had difficulty reading balance dials.

2. Student Activity:
(in all classes observed)
-attentive to presentation, worked on exercises in ALCHEM 10 text, put HW on Bb.

3. Use of ALCHEM:
-used exercises from ALCHEM Unit A to develop concept of electron distribution in energy levels.
-has students add number of neutrons to the Bohr diagrams in the ALCHEM material.

4. Comments on Science:
-"atoms are lazy- just like people".
-with regard to blank spaces beyond elements 106 on periodic table, "they haven't made any elements to fit in here yet".
-regarding the discovery of isotopes, "scientists couldn't figure out why these two pieces of lead had different masses- it was kind of a mystery- when Chadwick discovered the neutron it sorted the whole thing out".
-cautions the students, "don't think that the electrons follow the circles (in the Bohr diagrams) around the nucleus".

5. Comments on Students:
-in response to my comment that the classes seemed very attentive, he said he had "sorted them out at the beginning of the year", by giving them some statistics on failure rates in chemistry courses.

6. Comments on Teaching:
-direct expository style, asks questions of students to get feedback.
-uses the "discovery" aspects of the ALCHEM materials to good advantage, e.g., relation between number of energy levels and period number, and number of valence electrons and group number from periodic table.
-extensive use of analogies, e.g., comparing protons to bullets, and binding force to glue.

7. Comments on Society:
-none noted.

8. General Comments:
-students seem to accept Kurelek's classroom routines without question.
-Kurelek is more reticent about his classroom practice and his reasons for it, than the other two teachers interviewed.

B. First Interview with Mr. Kurelek, February 21, 1983.

(The interview was conducted in Kurelek's classroom at Glenview C.H.S., during lunch hour.)

1. **Lantz:** I think the first question is, generally what do you think of the ALCHEM materials?

2. **Kurelek:** Well basically, you know, I like using ALCHEM and I think the only thing is that we have problems with delivery. It's kind of annoying after awhile. Like last year in the second semester when I started. The ALCHEM wasn't here until three weeks into the course, because they were so back logged. I think we were almost tempted to change to a textbook because the textbook you have, sort of, in the class, whereas if you have to keep waiting for ALCHEM, or something, your hands are pretty well tied.

3. **Lantz:** They order from the School Books Branch?

4. **Kurelek:** Yes. But otherwise I find it really good because you know it sure saves me a lot of photocopying worksheets and stuff like that.

5. **Lantz:** So it's mainly in the area of worksheets for the students to work on and questions based on some concept?

6. **Kurelek:** Yes, that's what I really like about it. But basically I try and treat it sort of like a textbook for them. Like I tell them if I write something on the board that they take it down as notes whether it is in ALCHEM or not.

7. **Lantz:** How do you handle that - you just have them write on looseleaf pages and stick it in?

8. **Kurelek:** Yes, basically because the ALCHEM is all bound together. You know, they have their ALCHEM then the have a bunch of looseleaf in behind it. I think that's best for them anyways because it's so much more compact if you have a set of looseleaf instead of trying to flip through, you know, like 50 or 60 pages of ALCHEM, trying to study for something. Basically, I think its good, like I think that was the general idea of it was to be treated like sort of like a textbook and worksheets - at least I hope.

9. **Lantz:** No, certainly the way you were using it, at least the period that I saw you, is the way it was intended to be used. Those exercises are there to reinforce the points of major concepts and give the students some practice. There's some sort of built in discovery mode there. Like in that exercise today where after they complete the chart there are some questions on the relationship between the group number and the number of valence electrons, and the periods and number of energy levels. The generalization comes through from the exercise.

10. **Kurelek:** That's right.

11. **Lantz:** Now, are there any parts of the ALCHEM that you omit?

12. **Kurelek:** There are a couple of labs. That's, two labs in section B that I sometimes omit depending on the time. The one having to do with the scales. Basically I can see that the whole lab is to get practice in using the scales. While its good to have practice, I think they get bored of it pretty quick. I think they can pick up use of the scale in other ways.

13. **Lantz:** It's not necessary, as far as you are concerned, to have that much practice. That's the one on the balance, and you said there was another one?

14. **Kurelek:** Yes, there is actually two in there on using the balance - I can't remember exactly how the other one is set out now.

15. **Lantz:** Okay, I think you're right. One is maybe getting the mass of a mole or something.

16. **Kurelek:** But I can't remember. I think the other one has to do with moles. But those are about the only two labs that I tend to skip out on. The rest of them I pretty well do. And with another that I might the odd time, but usually I do. It's that one where they build the models.

17. **Lantz:** Okay.

18. **Kurelek:** Basically because I don't go into shapes usually and structural diagrams that much with it. So I don't really see any value in doing it. Because I think the way that they have it set up there is that they have... Okay, you have a reaction - hydrogens plus oxygens yield good old H20. And they want you to build a hydrogen molecule, an oxygen molecule, a water molecule so you can see all the atoms and how they have done it themself and everything. Sort of I guess a concrete way of...

19. **Lantz:** Looking at the conservation of mass or illustrating that you've got the same amount of matter before and after...

20. **Kurelek:** Yes. I sometimes drop out that one and only do a little of it. Because I think that's something that they can pretty well understand, and they get bored with the exercise. I don't think they have too much trouble with balancing equations and things. Like that's the only part of the unit that they don't seem to have much trouble with.

21. **Lantz:** Hmmm, is that because they have had a fair bit of that before?

22. **Kurelek:** Yes I think so because you get a lot of kids saying, "Oh I remember that from Grade 9", and stuff, you know. I think that's because they have done it before and they pretty well have an understanding of it.

23. **Lantz:** Now is there anything else that you omit?

24. **Kurelek:** No, the only other one that just comes to mind is maybe... There is an exercise on... you know, after they have the history of Mendeleev and then they have a little exercise and then... maybe something like that I skip out usually because I deal with history. I go through the model of the atom and that's pretty well all the history. And they have to know Mendeleev's name but I don't think they have to know what school he went to, and things like that.

25. **Lantz:** Alright, now what about supplementing the course as you go along, are there places where you have to add to ALCHEM?

26. **Kurelek:** Yes, well especially in the history part, and additional notes on moles, and I give them a lot more notes than ALCHEM does on the Atomic Theory. Like I go right into Rutherford's, you know, gold foil experiment. I draw it out for them and explain it to them and the same thing with the Crooke's tube. Colin mentioned it a couple of times today with the spectrum analysis and things like that, so I add a little more into the history too. So they get supplemented with that. Same things with the films a lot of the films have to do with this first section. Like the one, "The Strange Case of the Cosmic Rays", have you heard about it?

27. **Lantz:** Yes, umhumm.

28. **Kurelek:** I show that. How about Carl Sagan, you've probably heard about it?

29. **Lantz:** Oh, you use some of those to, do you? hmm.

30. **Kurelek:** Yes, "The Cosmos", the one that he did on atoms. We showed that one too.

31. **Lantz:** Now there is one film which is called "World Within World" that's about the

development of the atomic theory. The first reel of that works quite well with Chem 10.

32. **Kurelek:** World Within A World?

33. **Lantz:** Yes, World Within A World - I think. It's in the EPSB Film Library.

34. **Kurelek:** Labs. I can't think of any other labs.

35. **Lantz:** Do you feel pressed at all for time in Chem 10? Do you get through the course?

36. **Kurelek:** Actually no, I have found that it works out pretty well. In fact, some times I have a week or so left over. (PAUSE)

37. **Lantz:** Now these notes that you do with Rutherford and Bohr, you write them on the board and they copy them down as lecture notes? Now I noticed some equipment like those cathode ray tubes on the desk. So you do some extra demos then?

38. **Kurelek:** You know where you have this - I can't remember what they call this little thing here where you show that like charges repel....

39. **Lantz:** Oh, an electroscope.

40. **Kurelek:** Yes, electroscope. And I hook up the gas discharge tubes to show the hydrogen spectrum and that's about it.

41. **Lantz:** Yes, that fits in well with the first unit, especially when you explain the lines in the hydrogen spectrum and relate that to the energy level, you can tie that in quite nicely. Now are there any parts that you adapt or modify?

42. **Kurelek:** Well there's usually a little modification. For example, this one we are doing here in the ALCHEM. They just want them to list the protons and the electrons and then they get them later to do some work on the neutrons but I get them to do the neutrons also even though Bohr didn't include them in his model, because they weren't discovered 'till later.

43. **Lantz:** Yes that's a good place to work it in right at the beginning, and they don't seem to have any trouble with it. They were handling it quite well.

44. **Kurelek:** Other than that I can't think of anything off hand. There is some on section E. I give them supplementry handouts and stuff that's on mole calculations because they have really a lot of trouble with that conception. I guess it is a problem they have with math in general. I think it's a big problem to this degree.

45. **Lantz:** Now in that mole to mole calculations and so on there is a lab there as well that comes pretty well right at the end of Unit E. Do you get to that one?

46. **Kurelek:** Oh yes, yes we do that one. And we do the demonstration too. Yes, that's a good little lab.

47. **Lantz:** Yes, if you get to that point, and have time to do it, it ties together the whole course pretty well. (PAUSE) Now I think the next question is about elective units. Do you have time for elective units in Chem 10?

48. **Kurelek:** No the only place we do any is in Chemistry 20. I had some 20's last semester and we used that unit where they do the qualitative analysis and quantitative analysis.

49. **Lantz:** Oh yeah, the quantitative analysis unit.

50. **Kurelek:** Analytical chemistry unit.

51. **Lantz**: Okay, you have the kids get the little unit?

52. **Kurelek:** Yes and they work right out of that do the labs and things.

53. **Lantz:** Now did everybody in the department do that... or did you decide...

54. **Kurelek:** Yes, everybody in the department.

55. **Lantz**: Do you consult quite a bit with the other Chem 10 and 20 teachers about what you're going to do and how you're going to handle it?

56. **Kurelek**: Yes well not as much this year, but I did a lot last year.

57. **Lantz:** Are there common exams for the finals?

58. **Kurelek**: Just the final is the only common exam. (PAUSE) And they have done most of the preparing on that one.

59. **Lantz**: The other teachers?

60. **Kurelek**: Yes.

61. **Lantz**: So there is sort of a pretty much a set exam for the Chem 10 final.

62. **Kurelek**: Yes.

63. **Lantz**: How many people are there teaching Chem 10?

64. **Kurelek**: There could be any where up to four because there is myself, (name omitted), the department head sometimes teaches one, (two names omitted) in fact it could be five because (name omitted) could teach too. So five possible teachers. But it seems myself and (name omitted) usually make the majority.

65. **Lantz**: Okay, anything else that comes to mind looking back at these questions?

66. **Kurelek**: No it seems pretty well all. You know basically I think ALCHEM is pretty good and I try and use it as much as possible.

67. **Lantz**: Yes, I see you have the ALCHEM Periodic Table here on the wall. That ties in nicely with the ones the students have. The problem I have is that the writing is so small.

68. **Kurelek**: Well yeah.

69. **Lantz**: It's hard for the students to see it unless they have their own handy. Now I noticed that this room is used for the chemistry but science 11 is in another room. Is that set up for Science 11 particlarly?

70. **Kurelek**: Yes, basically because of the labs. Otherwise the labs... someone has to set up the labs... It's just to keep the labs all set up.

71. **Lantz:** There is a lab between this classroom and the next classroom. I used to teach in the other wing on the main floor. It's the same set up.

72. **Kurelek:** Yes, it's the same set up and they have one in the other one that is specifically for Science 11.

73. **Lantz**: Classes run about 30 students?

74. **Kurelek**: Ah yeah. Mostly the academic runs about 30 students. Somewhere actually they have been usually pretty high like I usually have between 30 and 35 students... Which if it's a good class it's okay but if you have a lot of turkeys in

there... There is always...

75. **Lantz:** These two classes seem very cooperative anyway, the two that I saw, I don't know if it's because it's Monday morning, or are they always like that?

76. **Kurelek:** No they have always been like that. This is part of the third week that I have had them so... I haven't had any trouble with any of them... They are here on time and... I can't complain. I have all my marks down on computer and it prints out nice little statistics here.

77. **Lantz:** That's on the Apple?

78. **Kurelek:** Yes.

79. **Lantz:** Is that the program that (name omitted) developed?

80. **Kurelek:** Yes, and (name omitted).

81. **Lantz:** Yes, (names omitted) worked together on that. It's pretty good. I have never used it because I wasn't teaching since they wrote it. But I know that I have seen some of the information that they can get off that.

82. **Kurelek:** It's quite handy. It sure saves a lot of time when you have marks to do.

C. Second Interview with Mr. Kurelek, April 6 1983

(The interview was conducted in the science teachers' workroom at Glenview C.H.S., during Kurelek's preparation period.)

1. **Lantz**: Okay, one of the things you mentioned when we talked last time was that you use ALCHEM, "sort of as a text". I wasn't quite sure when I looked over my notes what you meant by, "using it as a text". Can you elaborate on that a little bit?

2. **Kurelek**: Yeah, basically I sort of learned from the... "Are you familiar with the CRIB Program? When I was doing the 7,8 and 9... you know how they sort of have everything put into units? And quite often the teachers there are very good at (unit) packs and hand them out to the kids and everything. I sort of made the mistake of assuming that those were their notes, kind of thing. If you know what I mean. Like that they didn't really have to take any notes or anything because they had all the information sorta there. And then I began to realize that after awhile that wasn't such a good idea so now what I do, even though they have a lot of the material in the ALCHEM already, I give them the notes just like they didn't even have it, sort of. So like you'd have a textbook as a reference, I sort of treat the ALCHEM as a reference.

3. **Lantz**: Now a number of people have commented, as I've talked about ALCHEM, that they think ALCHEM materials are too sketchy, that they don't give enough by way of background to the student. How do you feel about that?

4. **Kurelek**: Well, it would be nice, I suppose, if they would get into a little more detail. But then, you know, I suppose they are sort of leaving it up to the teacher. They begin to give them what they feel should be the correct notes. I suppose if they they're probably looking at it if they make it too indepth then it will turn the students off.

5. **Lantz**: Yeah, they were designed to be quite brief just the same and certainly the intention was that the teachers would supplement them as they went along. They have grown over the years, you look at the early additions of ALCHEM, they were very sketchy. I think as people have asked for more of that there has been more background material added in.

6.. **Kurelek**: So for myself I don't really find it too sketchy I think it is just about appropriate.

7. **Lantz**: Okay, um... some people have the notion that a text should have hard covers on it. I guess the people who developed ALCHEM were of the view that it was better to have a text that you could intermix additional notes and the labs were integrated right into it and that is why it doesn't have covers, but it still seems to turn a number of people off because they expecting something more like those books on the shelf there.

8. **Kurelek**: Well I think in that respect I think they are smart not putting the hard cover because I think you are adding probably to a cost at least a dollar or two just to put on a hard cover and, like I say, I think it's better the way it is. You can stick your notes in there and let's say if you want to go to the lab and bring it along with you it's easier to carry that way. So I don't mind it not having a hard cover at all.

9. **Lantz**: The new format isn't as good as the old one as far as I'm concerned. In that its... its in a booklet, you know, and its harder to intermix your own pages and stuff. That was a thing that the publisher did. I guess it is easier for him to run it off that way, than as individual pages in loose leaf format. Now you mentioned also that when you are introducing the students in Chemistry 10 to atomic structure, you do a bit more than in ALCHEM on the history of atoms with Rutherford and Bohr and Chadwick, and so on. What kinds of things are you intending to do there with the additional information?

10. **Kurelek**: Well, a couple of things really. I want to give them an appreciation,

basically, of how a theory develops. Rather than just saying, "This is what an atom is". I think if you can show them how a theory developed, there's more opportunity for them to say they agree with it or disagree. Chemistry isn't really a controversial topic. Let's say if you wanted to do something like evolution, say for example, then it would be. They would have a chance to express their own views. Probably none of them are going to argue with Rutherford's experiment and how it was done or anything like that but still...

11. **Lantz**: Alright, so it's to give some sense of the nature of science and how scientific theories develop and build on each other.

12. **Kurelek**: Because I think in every science course you sort of have the obligation to, you know, go into the scientific method a little bit, because if they get anything out of the course, you know, they're probably not going to remember too many things they had to memorize. But at least if they get an appreciation of how science works, then when some scientist stands up and talks about something, well at least they will be able to realize how a theory came about or something. Also I think it doesn't hurt to give people credit for what they do, you know. Everybody knows who Wayne Gretzky is but not many people know who Rutherford is, and if I just said, "this is Rutherford's mode",I probably they wouldn't remember it. But if you can show what experiment he did, maybe they'll get a little. Maybe that might make them remember his name a little more.

13. **Lantz**: Yeah, it is interesting how a personal anecdote about someone catches people's attention. And so they fix that in their minds more than, for instance, a theory or an equation or something to that effect.

14. **Kurelek**: And like I told them, everybody knows Gretzky's name, but who has more affect on their life? Somebody like Gretzky, whether he scores a hundred goals or not, or somebody like Rutherford? They may not realize it but he probably had a lot more affect on their lives than certainly Gretzky did.

15. **Lantz**: I quite agree with what you're saying there. Do you feel that the university formed your attitudes to teaching science, or is that something that's more or less your own?

16. **Kurelek**: Yes and no. It's kinda funny. It's sorta something that sticks in my mind as a student in a genetics class at university. One of our students said, "Why are you talking about history? Why don't you just tell us, 'this is the way it is', and that's it"? His answer was, "Well here in university it's one thing you should never do is totally accept something as being true". He said, "In my life I have seen so may things in science that people accepted were true and later on they were shown to be untrue. So if I just teach you something as being true without showing you how we arrived at this conclusion and arguments against it... You know you're never going to question whether that's true or not. You're just going to accept it as true. But if you're shown how this idea was arrived at maybe you can disagree with it then".

17. **Lantz**: That's great. I didn't have that experience in any chemistry courses I took. Ideas that I got about the nature of science and that sort of thing were from Dr. Nay, in one of the senior methods courses which I took from him after I had been teaching for a couple of years. But my sense is that chemistry people at the U of A are really not much into the history or the nature of science. Interesting to hear that there are some genetics people who are. I suppose genetics is a more recent thing and a lot of these things are still evolving and there is a lot of question about it.

18. **Kurelek**: That's true, more controversial. Like I say chemistry isn't all that controversial.

19. **Lantz**: Well the level at which we teach in the high school is pretty cut and dried. Beyond that we can give the history of various theories. Now you mentioned using films... Do they try and bring out the same ideas?

20. **Kurelek**: The "Cosmic Ray" one does, yes. I think that sparks a little bit of interest in them. Because I remember, when I went to school, seeing that film and I found it really highly interesting. Like I assumed that particles like protons and electrons and neutrons and that... You read in the paper all the time about scientists discovering a new particle, and all that. And it doesn't really hit home as to what they are talking about 'till you see something like that film and then you sorta get an idea. The universe is just not quite as simple as it first appears, you know.

21. **Lantz**: The one too... With the Sagan film I think there is a real sense of wonder at the size of the universe. That's something that ought to be part of science teaching and often it gets so routine for the teacher to forget about that. All the awesomness of nature doesn't come through when you're teaching. It's neat when there is a film that does that.

22. **Kurelek**: I think with Carl Sagan too they get... I don't think they often get exposed to somebody who just seems so totally enthusiastic about what they're doing. In fact when the film first starts you get a couple of guys looking around, "Is this guy for real?", you know. Because he just seems so *into* what he does. I'm sure he is. They can't believe that...

23. **Lantz**: That anyone gets that wound up about science or whatever their line of work is. I was going to ask also about Lab E. You mentioned that you usually do that one on stoichiometry. Do you find that the students can be accurate enough to get the point that lab is making about the mole ratios? Does that come through pretty well?

24. **Kurelek**: Ah, I suppose it is like anything else, some students are conscientious enough and sorta realize the purpose of the lab right off the beginning, and know all the techniques have to be perfect, sorta, in everyting in order to get good results. Then there are other kids who just don't care and... For those kind of kids the lab doesn't give good results. I think that the whole problem is that they just don't get enough exposure to stuff like that probably. Sometimes if you don't get enough practice at it you don't feel very good at it. Some people are just naturally good at it.

25. **Lantz**: They're quite adept at it. I guess I was wondering about that lab in the context of what you said about leaving out the one on the balances. Now that one... I guess what you are saying is that basically they can learn how to use a balance, but the kind of fine skill that they need in lab E is harder to bring out. That more analytical work is what they need.

26. **Kurelek**: That's right, because you know with Lab D there's no real motivation there. I think they become pretty bored with it, you know. Whereas with the E there is a little bit more motivation even though its quite a staightforward lab.

27. **Lantz**: You think the problem with that Unit D lab is that it is too simple? That it isn't even challenging?

28. **Kurelek**: Yeah, I think that's the big problem with it. Unfortunately, I don't have any ideas how to improve it.

29. **Lantz**: Possibly use the time with another lab like Lab E. Something like that, that has more of a point to it. I was working with Dr. Kass's methods course and taught some of the classes. And I had the students work through Lab E as sort of a little sample of what you'd expect good chemistry students to be able to do. And they did it and they got quite good results, even though the equipment in the education building isn't that hot. The balance are triple beam but they were very careful because they were sort of competing with each other, and most of them had done analytical chemistry. It was interesting to me to see that the lab actually has a potential of making the point fairly well about the mole ratios. They come up pretty close to what you predict. So with some technique and some reasonable equipment students can get reasonable results.

30. **Kurelek**: Usually the good ones come out to, you know, somewhere around between 95 to say 98% accurate which isn't too bad, within the moles . So lets say it gives them a good appreciation of what you're saying about chemical equations.

31. **Lantz**: It's a two to one ratio in that case, things are...

32. **Kurelek**: Yeah, it's a two - one ratio

33. **Lantz**: Are there any other things since we talked last time? I was asking basically about what you modify and adapt. Anything more come to mind since we've talked?

34. **Kurelek**: Hmmm, not really. No.

35. **Lantz**: Where abouts are you in the course now?

36. **Kurelek**: Just getting ready to start Unit C. Actually next week.

37. **Lantz**: I remember that we were just into Unit C for mid-terms. About next week sometime.

38. **Kurelek**: I think this school started a week behind all the other schools anyways, so for some reason our semester break was a week later then anybody else's.

39. **Lantz**: That's right, I remember. Which of Unit C (labs) do you go through? That fairly long lab where you look for evidence for reactions?

40. **Kurelek**: Yep, that's what we do.

41. **Lantz**: You find that quite productive with students?

42. **Kurelek**: Yeah, quite good

43. **Lantz**: Do you use gunpowder?

44. **Kurelek**: Ah, she (the lab aide) was just asking me if I wanted to use that one and we have sometimes, but last time we didn't because she couldn't get it set up. But I think she is going to set it up this time.

45. **Lantz:** Yeah, that adds a lot to it...

46. **Kurelek:** Yeah, adds a little excitement.

47. **Lantz:** Now one thing I noticed when I was sitting around the class last time... You make quite effective use of analogies when you are teaching the class and... I think you were talking about why the atom forms stable octet. I think you said something like, "atoms are like people - they're basically lazy." Do you make quite a bit of use of analogies as you go through?

48. **Kurelek:** Yeah because I found... I think this is what you said sort of about... You were saying about anecdotes... they sort of make you remember it. I think if you give an example about some things, even though it makes you seem a bit crazy or something. I think it helps them remember it, to fix it in their mind. I like to use that as much as possible.

49. **Lantz:** Yes, analogies can be quite effective and that is something you can pick up. A lot of things I appreciate about being able to go around this year and watch student teachers and people like yourself - picking up ideas that I can use when I go back teaching on how to approach a topic.

50. **Kurelek:** You are, um, a faculty consultant?

51. **Lantz:** Yeah, I've got five student teachers right now.

D. Third Interview with Mr. Kurelek, May 24, 1983

(The interview was conducted in Kurelek's classroom at Glenview C.H.S., during lunch hour.)
(When a previously scheduled interview with Kurelek had to be postponed, the SOS summaries were left with him so he could look at them in advance of this interview.)

1. **Lantz**: Were there any surprises in that summary of the student opinions on the ALCHEM text?

2. **Kurelek**: Well, things like "gaining an understanding of chemistry" was rated down. Worked out examples and math problems, and the math problems themselves, were fairly low. Well, maybe it's because they haven't done Unit D yet. Maybe that's why they don't realize how important those math problems are.

3. **Lantz**: That's true. That's the problem with that Chemistry 10 questionnaire, it comes before they have really done much of that kind of thing. That's mostly in Unit E, as you say, when they get the stoichiometry questions. I guess examples, generally... they probably see those as being useful. They assume the math examples will be useful, too.

4. **Kurelek**: So I suspect they would probably increase on that maybe if it's taken after Unit D.

5. **Lantz**: We were talking about this in the hall...that the "biographical sketches" (rating) doesn't surprise you. In terms of understanding chemistry they wouldn't...

6. **Kurelek**: Yes. The, "interesting", part too, is about right. It's fairly interesting information, whether it's all that useful or not, but interesting anyways. Maybe that's why it was rated high on the test.

7. **Lantz**: That's right, they gave it a 3.0 in terms of "interesting" and a 2.8 in terms of helping them understand chemistry. In terms of exams, the same general pattern held, I think, for that. Anything else in, "gaining an understanding of chemistry"?

8. **Kurelek**: I pretty well am in agreement with what they are saying here. I would rate, myself, 14 (biographical sketches) as being the lowest and 13 (lab on safety and efficiency in the laboratory) as the second lowest. Maybe, those two are so close together they might probably switch them.

9. **Lantz**: That lab on safety and efficiency in the laboratory, is that one you work through?

10. **Kurelek**: Yes, but as far as understanding chemistry, I don't think it's of much use. But it certainly is a valuable exercise.

11. **Lantz**: Yes, but they don't see it as very interesting, really. I think students are looking for something a little bit more exciting when they go into the chem lab. They are expecting some colour changes or some fizzes and pops at least, and not "Where is the fire extinguisher?" or "Where is the eyewash bottle?".

12. **Kurelek**: Even though that knowledge might save their life.

13. **Lantz**: That's right.

14. **Kurelek**: "Illustrations"? I agree. I also don't find them as much use. I think the ones in ALCHEM are fairly poor.

15. **Lantz**: Yes, I agree.

16. **Kurelek**: I don't really know too much where they come in. That's maybe left up to the teacher.

17. **Lantz**: I think so. I would say that that's one of the things that marks ALCHEM as still kind of an amateur... that the illustrations are that poor. And in the revision I think it would be worth getting a good artist to redo all of that.

18. **Kurelek**: Like I said, the math problems come a little bit low. Certainly, for "gaining an understanding of chemistry," because I don't think any of them really read over those objectives at the beginning of each unit. I don't go over them with them. I'm surprised they rated them higher than the math problems. Perhaps they are reading them on their own. I don't know.

19. **Lantz**: Yes, they might do.

20. **Kurelek**: You know a lot of them (may have started) in Junior High because they used the CRIB. They always have the objectives listed at the beginning. When I was student teaching there was a lot of teachers who go over the objectives. Maybe they have made a habit of doing it on their own.

21. **Lantz**: Yes, that could be.

22. **Kurelek**: It would be valuable but I just don't really have time.

23. **Lantz**: That's not something you read to the class. Do you use them when you make up the test? Is it sort of a guide?

24. **Kurelek**: To tell you the truth, no I haven't. I probably have never even noticed they were there.

25. **Lantz**: There are certainly other ways to make tests. You could say, "What did I emphasize? What's the important stuff?"

26. **Kurelek**: That's mainly what I do.

27. **Lantz**: I know they were used to make up the test item bank. The objectives were used as guidelines for making up those questions but I think in a classroom, the teacher probably has a more direct sense just from the way he emphasizes.

28. **Kurelek**: I essentially use the same kinds of problems as on the worksheet and things like that. Same format, maybe just change the chemicals.

29. **Lantz**: One that I am interested in here is the one that sort of relates to science in society: "the information about sources and uses of chemicals" - number seven. Number six for "exam prep", and number three for "interesting". How do you handle that? There is always a table. It's the column down the middle that tells you what the stuff is good for.

30. **Kurelek**: Yes, I don't usually use that, but ocassionally I'll mention it. Say hydrogen peroxide or something, it's used to bleach hair. So I sort of do it on my own. Probably, they are reading them on their own.. I find a lot of times it will say something like, "sodium chloride, table salt" and then you'll have a blank there for formula. Some of them will say to me, "What's the formula for table salt?" "It's sodium chloride." So they are reading the middle row instead of the names down the side. I find that quite a bit. They have a tendency to do that.

31. **Lantz**: So probably they are reading that over.

32. **Kurelek**: As far as "exam prep", I find perhaps they rated them a bit high, six. Because, I think, in none of my exams do I say...

33. **Lantz**: ...actually name them?

34. **Kurelek**: Yes. I don't say, "What is table salt?" I don't see... Perhaps it was because they were rating them high on the other one that they rated high for "exam prep"

also.

35. **Lantz**: Yes, that could be.

36. **Kurelek**: I agree with them on "gaining an understanding." I think it's probably more interesting material. So I agree with them on that. But I definitely agree that the periodic table is probably number one.

37. **Lantz**: Yes, it came in on top on all of the three categories with your class. What do you think it's about the table that would make them rate it so high?

38. **Kurelek**: Well, certainly for understanding of chemistry it's such a nice summary. It's got all the information on it. Same for "exam prep". I suppose it's how you want to interpret that. I mean, you can't very well study the periodic table but it's certainly valuable during an exam. I suppose that involves preparation, too, because you have to know how to use the periodic table. As far as interesting, I don't know why it would be so interesting. I suppose because it's so handy and easy to use that it makes it interesting.

39. **Lantz**: Yes, they seem to have appreciated the compactness of the table, with the ions on the backside, the short list of rules, and so on.

40. **Kurelek**: I agree, it's quite nice. I noticed on the standard deviation it is quite a bit higher for the, "interesting", than it is for the other two.

41. **Lantz**: That's true. That's quite a high standard deviation. I guess if I looked at the overall distribution, it must have been quite a spread of opinions on that one.

42. **Kurelek**: I would sort of agree with that. It's interesting but I don't think it would be necessarily number one, the most interesting. Perhaps that's why there is such a high standard deviation. As I said, sometimes when people, when you study questions in groups of threes sometimes when they circle a five for the first one they say, "Well, I'll just circle a five for the next one." Maybe the ones that were thinking a little bit more said, "No it's not a five, maybe a three."

43. **Lantz**: Yes, right.

44. **Kurelek**: So I think that is probably about right on the average.

45. **Lantz**: I guess on one thing that is not in ALCHEM at all... and I know that when I looked in other chemistry books I noticed it... was the business about careers. Giving students a little bit of a clue as to what kind of jobs would relate to that branch of chemistry. Like, if you looked at a book called, "Chemistry Today", by Whitman and Zinck, that has in just about every chapter a little note in the margin. It says that a certain kind of chemical technologist would be using knowledge of solution chemistry all the time. ALCHEM doesn't have that. Is that something that you incorporate into the class at all when you are going along? Career type information?

46. **Kurelek**: Not really but it's something to think about.

47. **Lantz**: I guess because it's not readily available that a person hesitates to do that. The things that I do know are kind of dated, so information of that sort is too. Realistically, for a Chemistry 10 class, the question is, "What could they look for in jobs in five years time?"

48. **Kurelek**: They probably don't know totally themselves. Obviously there's chemical engineers or something like that, chemists themselves but there is probably a lot of things which the students don't realize that are heavily dependent on chemistry. Do you have any references for that?

49. **Lantz**: "Chemistry Today". It's a high school chemistry text and it's being piloted in

some of the separate schools as a possible text to use in the 10 and 20. Okay, any other comments on that? Anything else?

50. **Kurelek**: I think pretty well most of them worked out. Like, I would agree with most of the ratings. Just maybe those math problems should be ranked higher.

51. **Lantz**: I think we can probably explain that by the fact that they haven't actually done much with that yet.

52. **Kurelek**: They are just starting on it now. They really get into it in Unit D. Because I think they are going to find that those math examples are going to become fairly valuable. I think everything else worked out the way I expected.

53. **Lantz**: Okay.